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SCIENCE

20 January 1961
Vol. 133, No. 3447

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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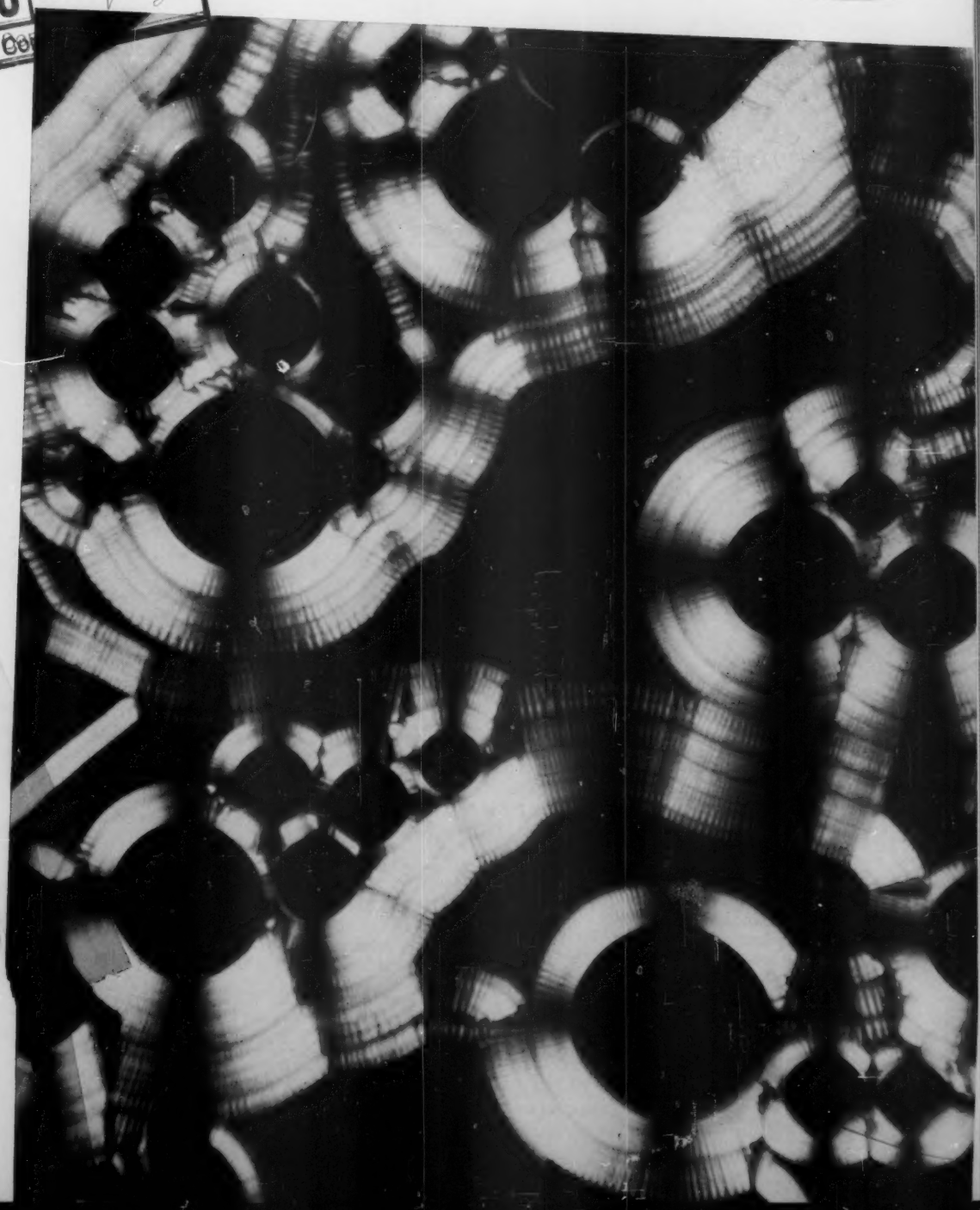

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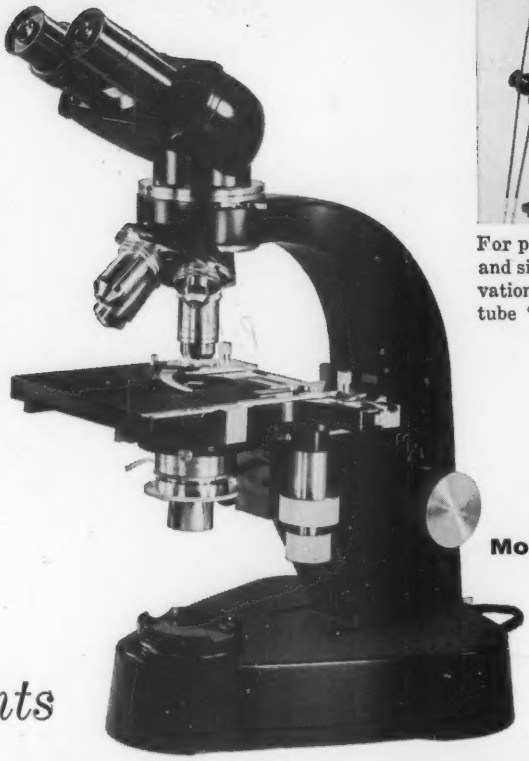

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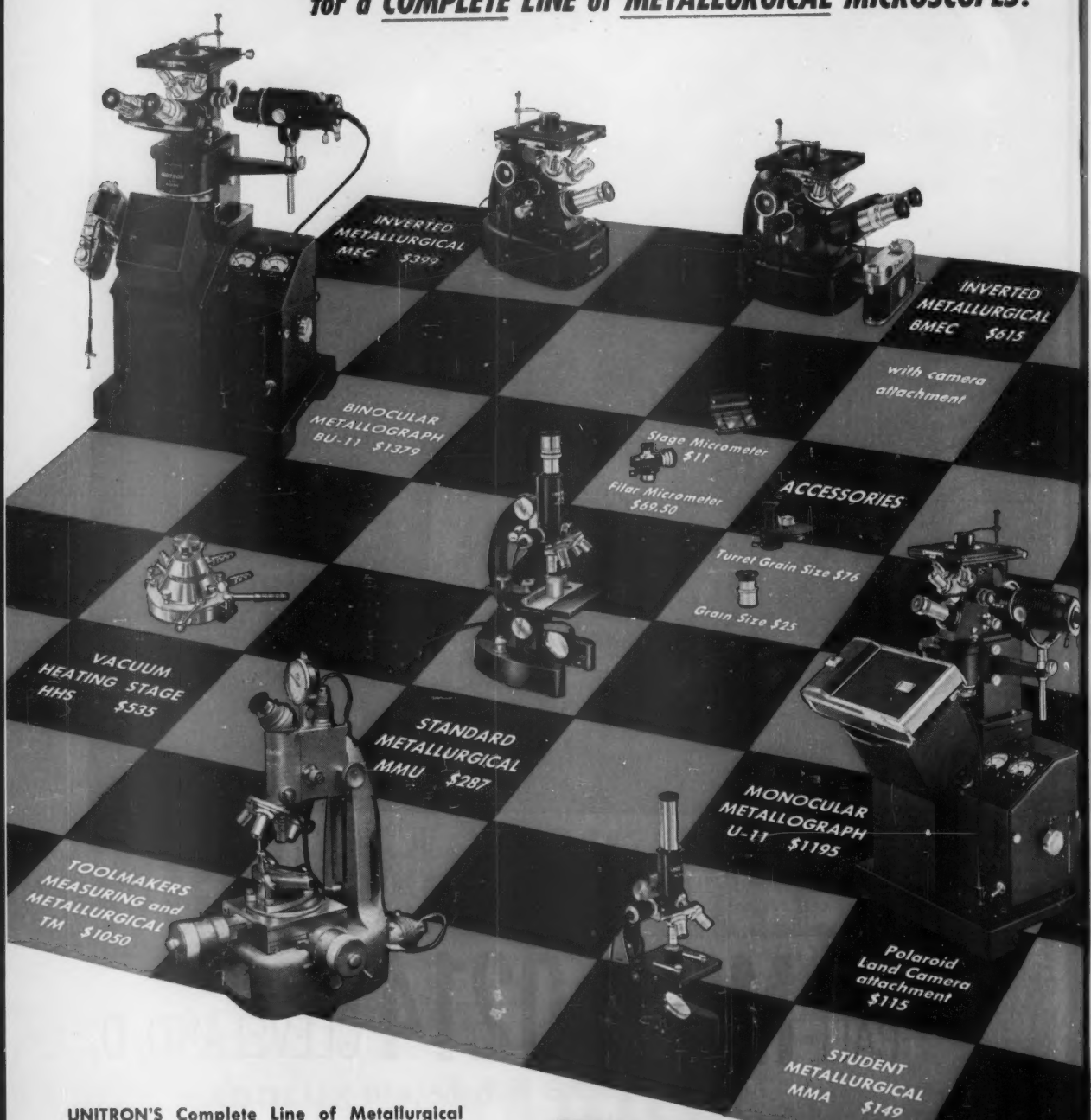

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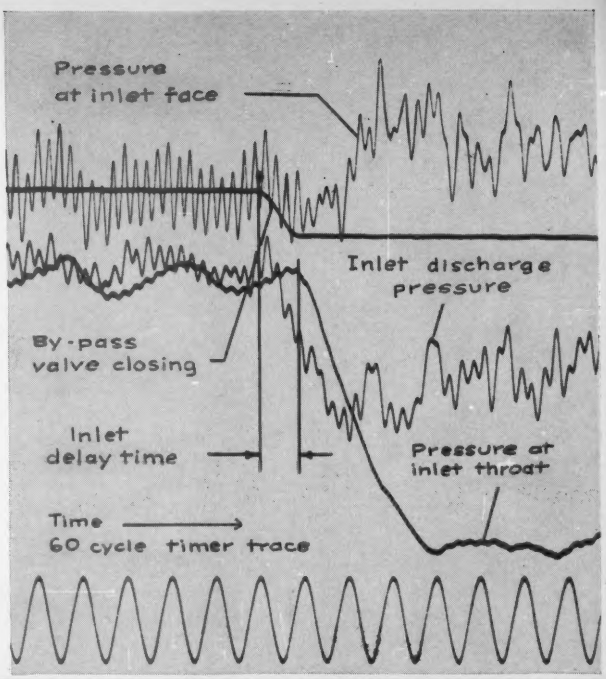

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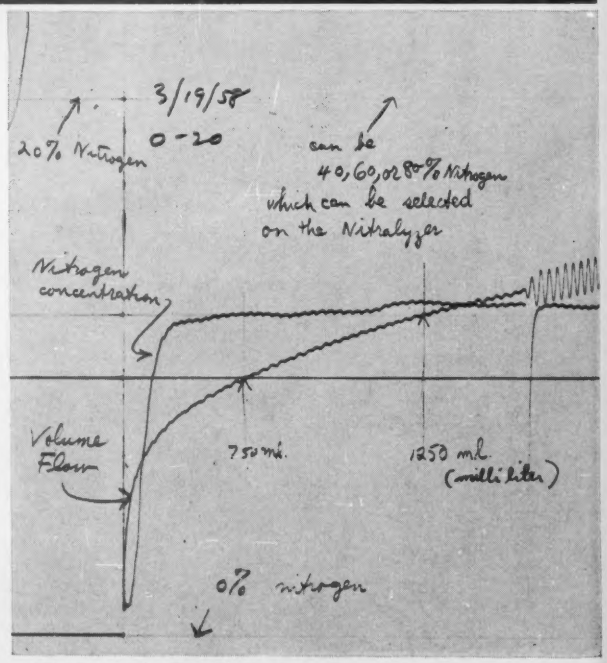

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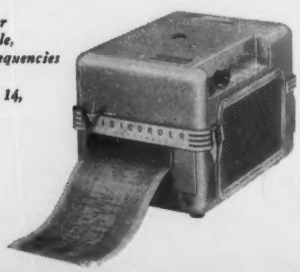

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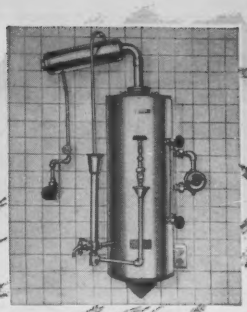

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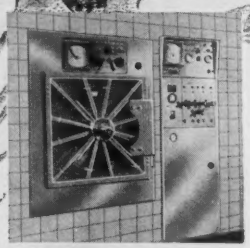

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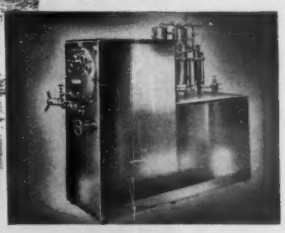

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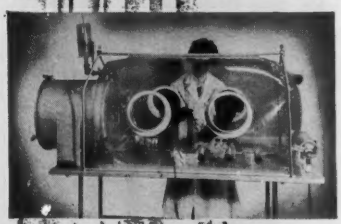

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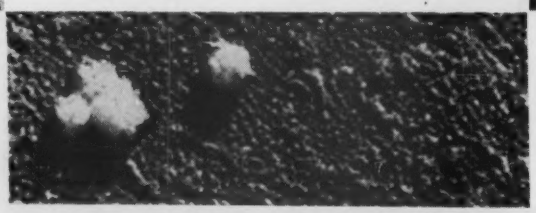

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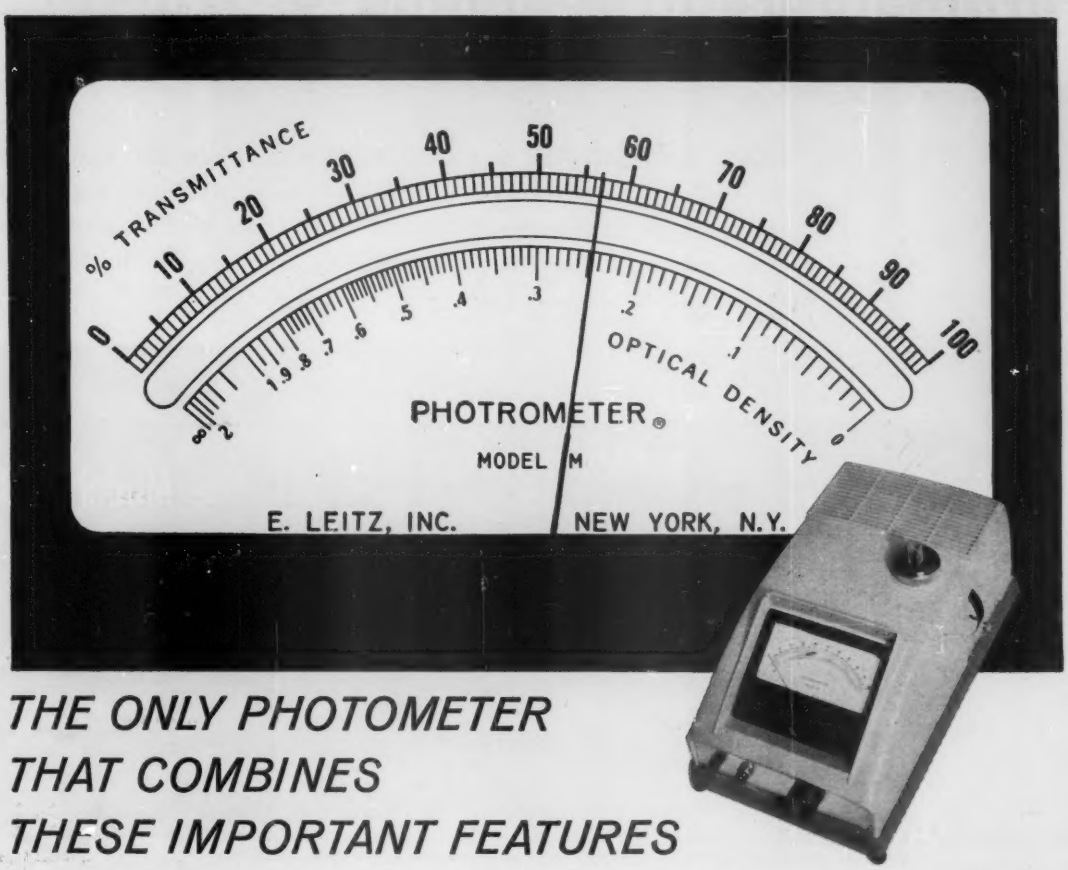

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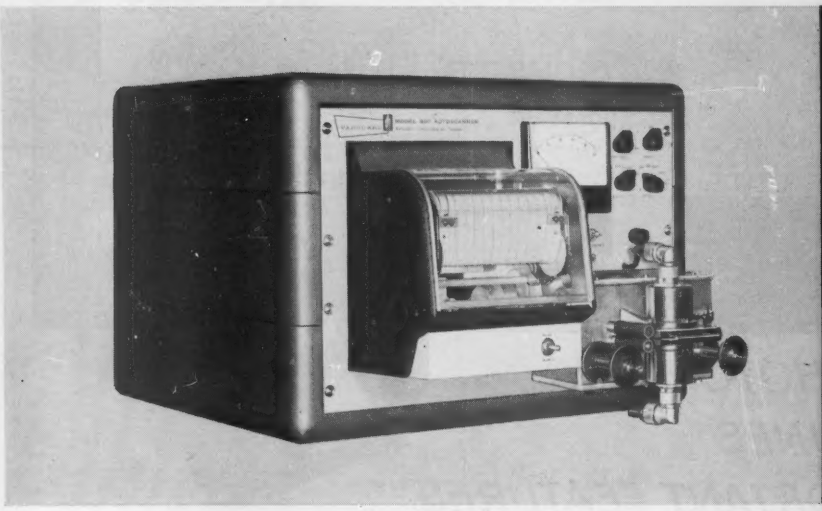

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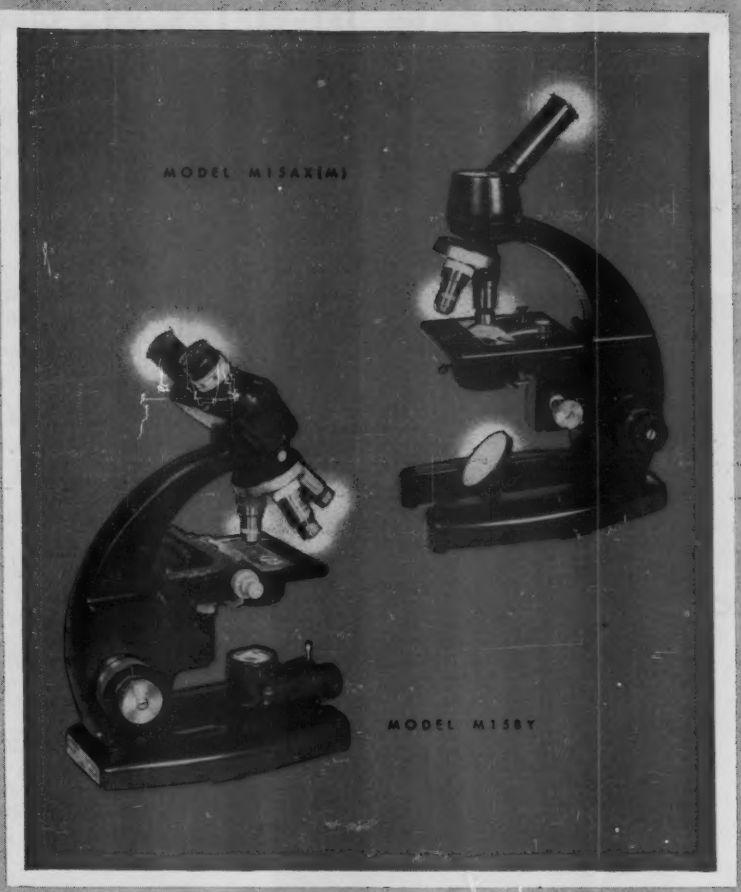

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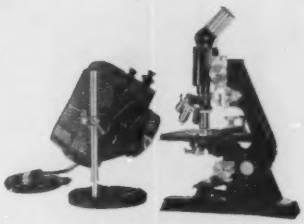

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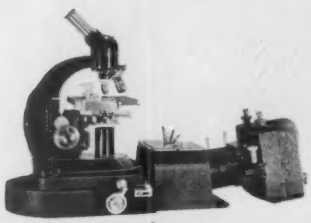

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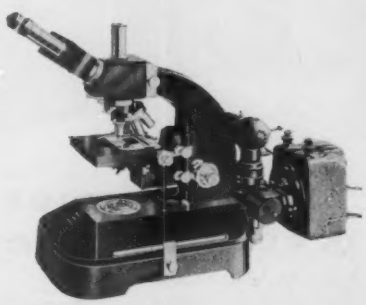

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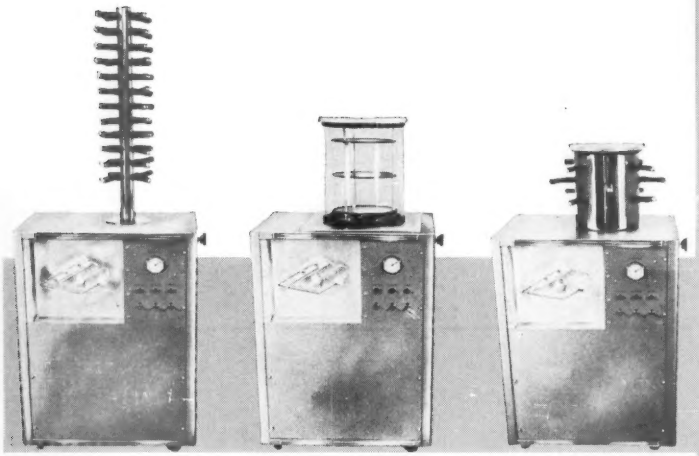

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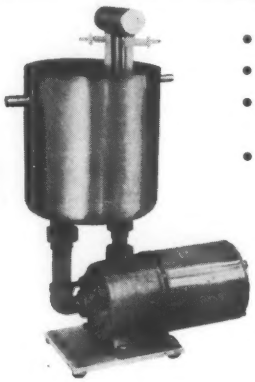

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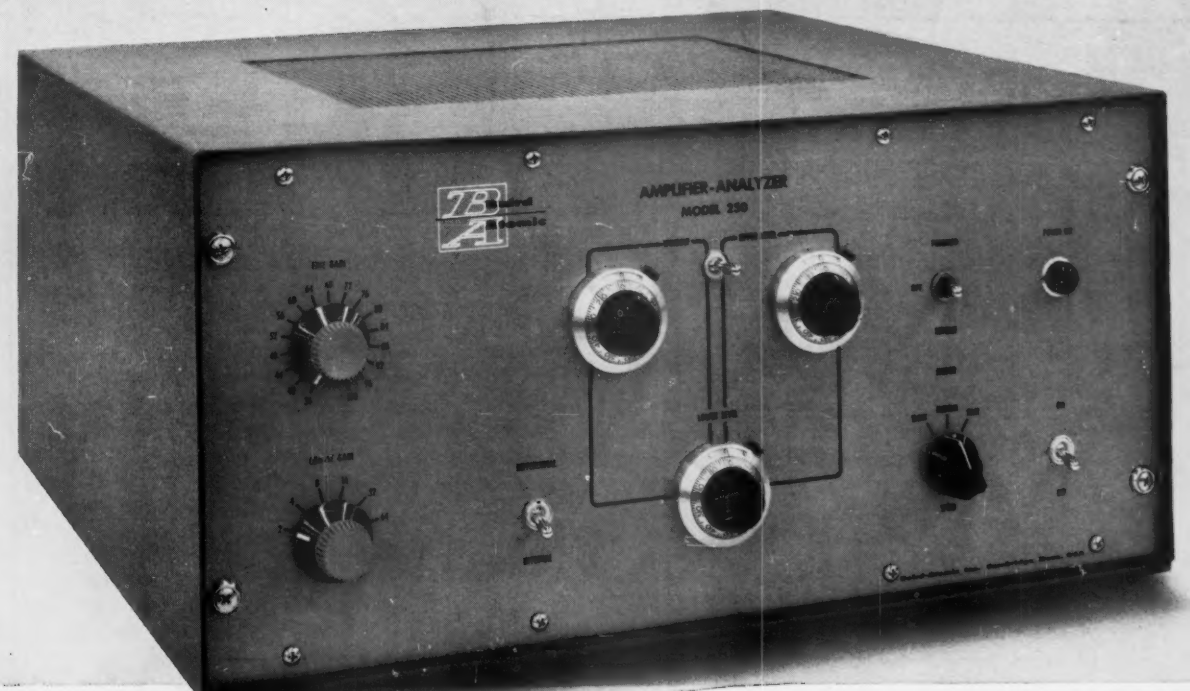

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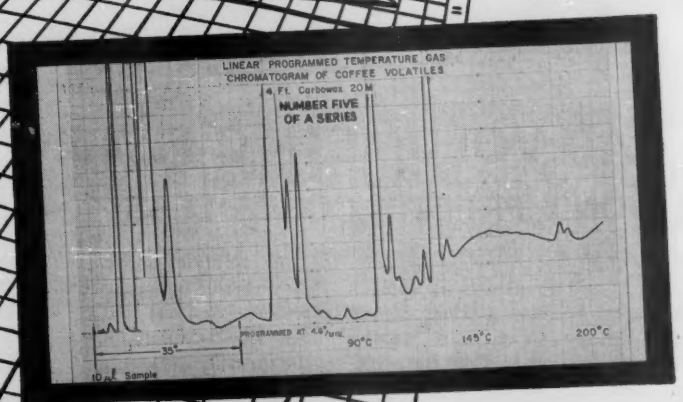

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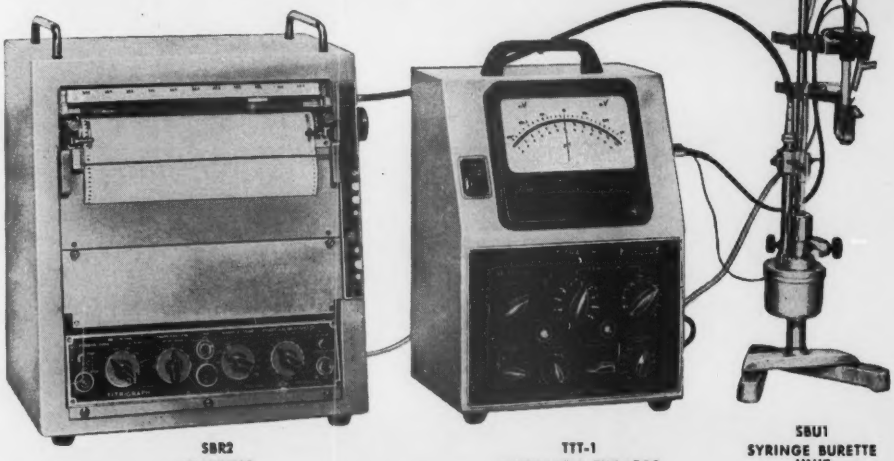

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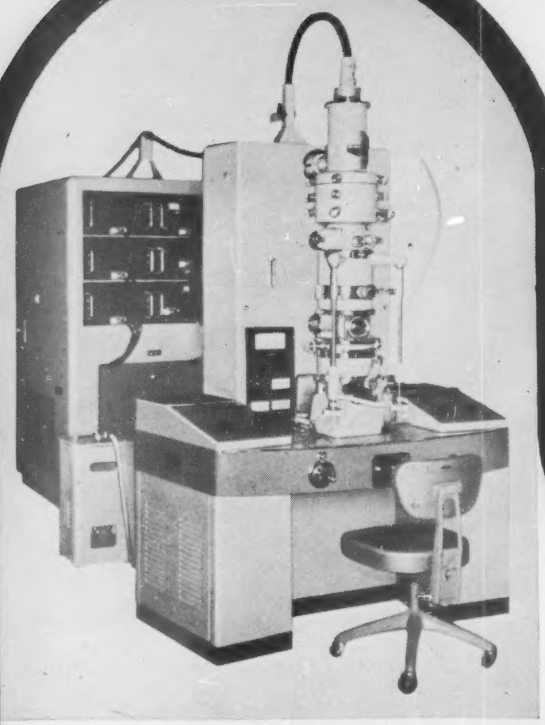

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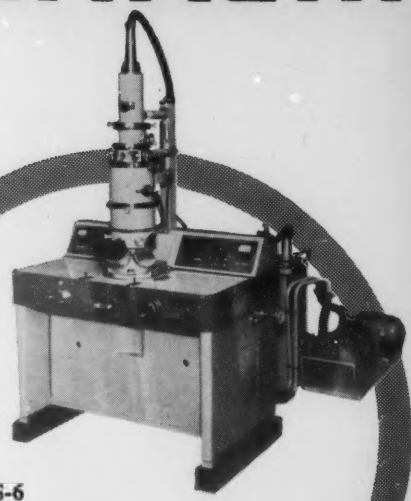

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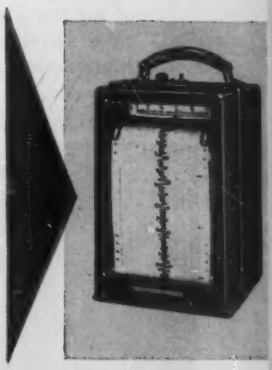

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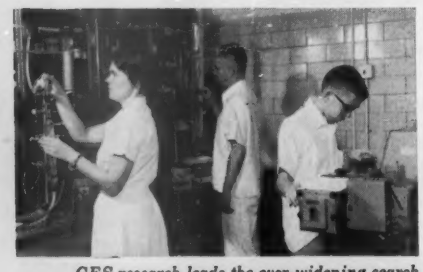

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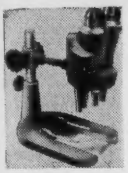

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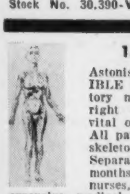

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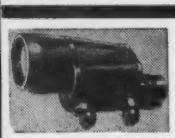

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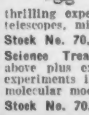

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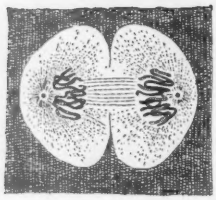
a glance at yesterday in relation to today



IN JANUARY—(1950)—a report[1] from the Karolinska Instutet in Stockholm discusses the effect of cold storage on mouse ascites tumor. There was a considerable loss of RNA but not DNA after 9 days at 4° C. Depletion of RNA is correlated with loss of virulence. Maintenance of a high nuclear DNA content indicates the cells survive the storage period and may possibly be interpreted as evidence of polyploidy.

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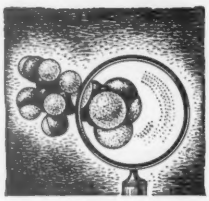

IN JANUARY—(1907)—*Chemical Abstracts* appears for the first time and summarizes[2] a paper by Emil Fischer on synthesis of polypeptides. This paper is of special interest because it describes the synthesis of the most complicated polypeptide ever prepared, consisting of a leucine and 11 aminoacetic acid residues. Fischer's new polypeptides closely resemble natural peptones in their water solubility and in failure to crystallize.

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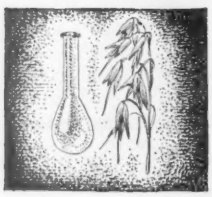

IN JANUARY—(1800)—J. J. Virey, of the Val de Grace, reports on the effects of animal aliments upon the human body. He states, "It is erroneous to maintain, that the nutritive quality is principally in the gelatinous substance of animals, since this is much less nourishing than the albuminous substance. The latter, when entirely animalized, requires only a light exercise, and a greater degree of oxygenation, to be converted into fibrous substance; but the gelatinous matter, being analagous to the mucilaginous substance of vegetables, requires a greater effort of nature for assimilation, and a more considerable separation of carbon and hydrogen."[3]

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1. Klein, E.; Kurnick, N. B., and Klein, G.: The effect of storage on the nucleic acid content and virulence of mouse ascites tumor. Exper. Cell Research *1*:127 (Jan.) 1950. 2. Fischer, E.: Synthesis of polypeptides, XV. Chem. Abstracts *1*:51 (Jan.) 1907. 3. Virey, J. J.: General remarks on aliments produced by the different classes of the animal kingdom, and their influence on the human body. Med. & Phys. J. *3*:65 (Jan.) 1800.

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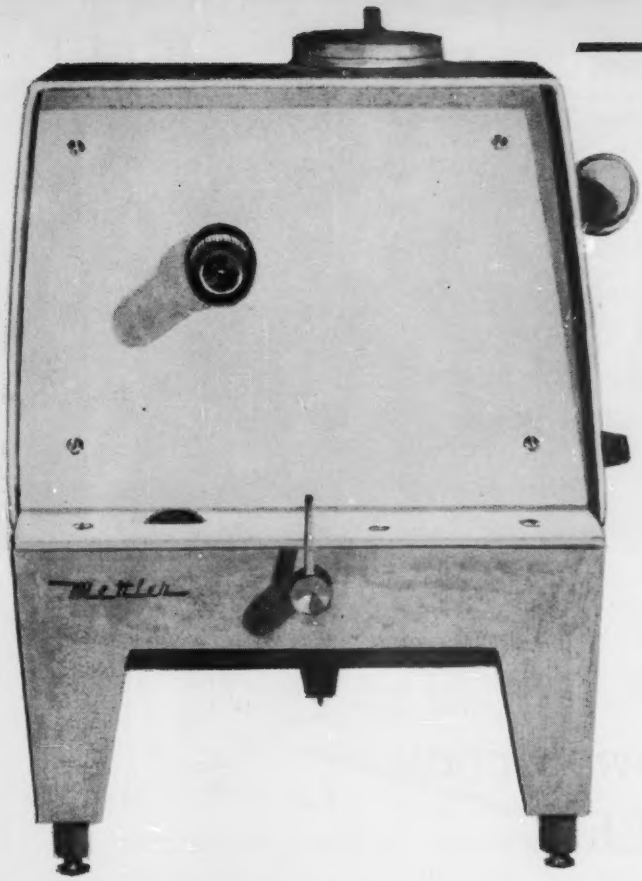

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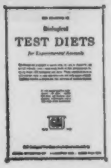

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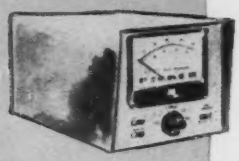

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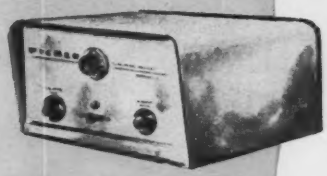

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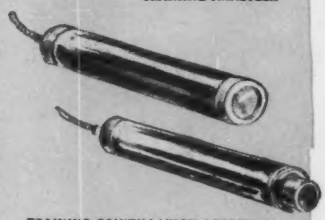

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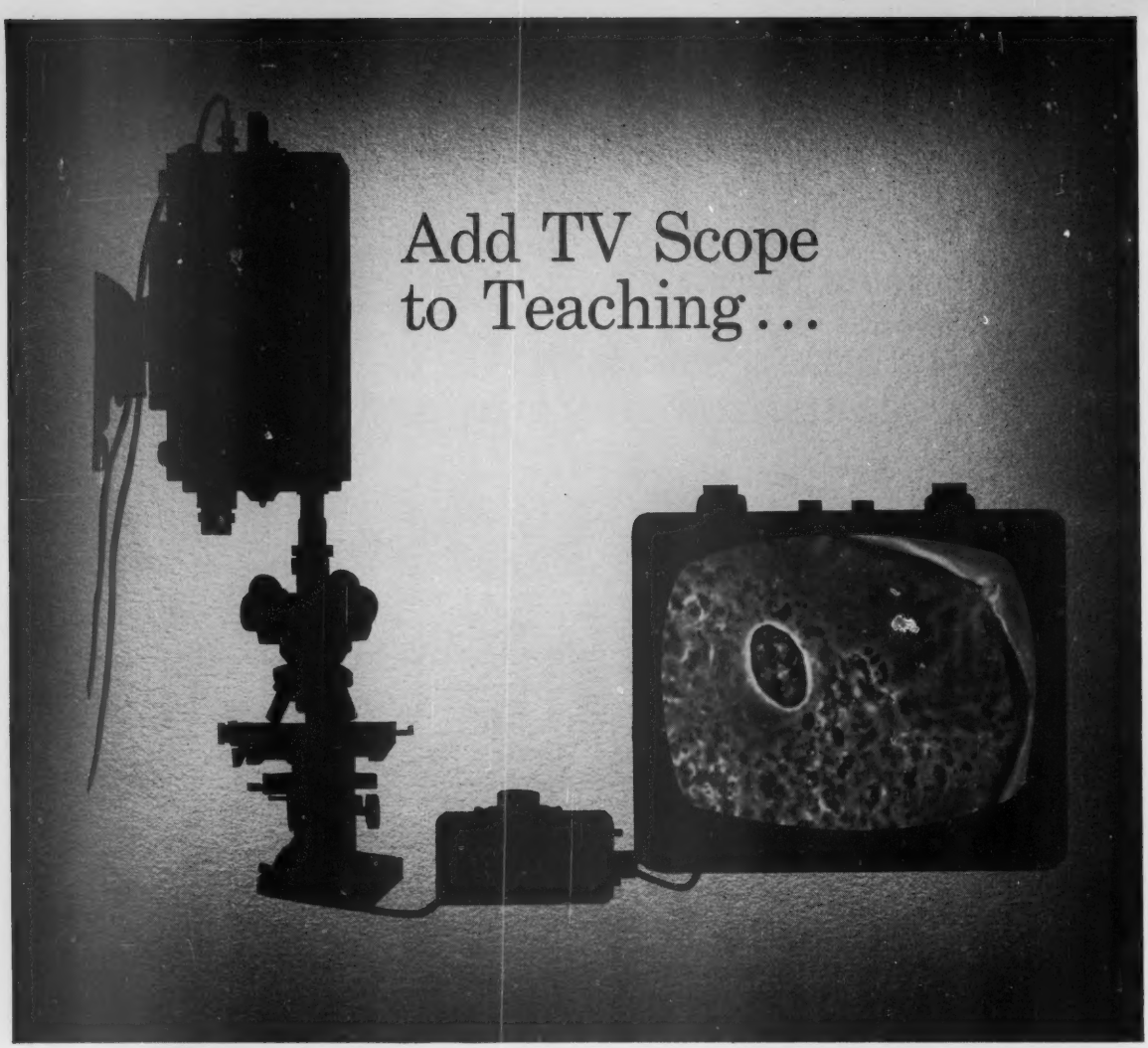

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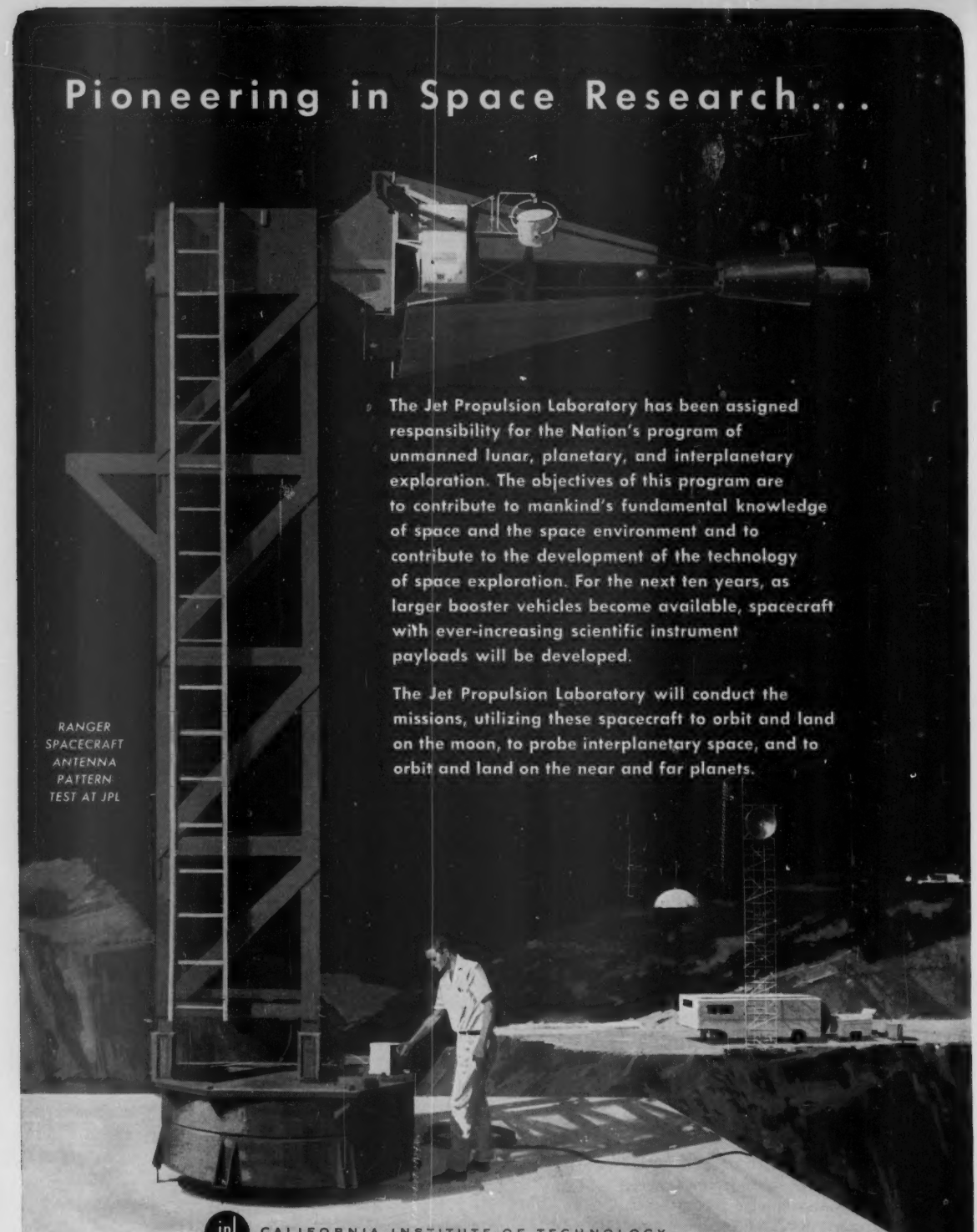

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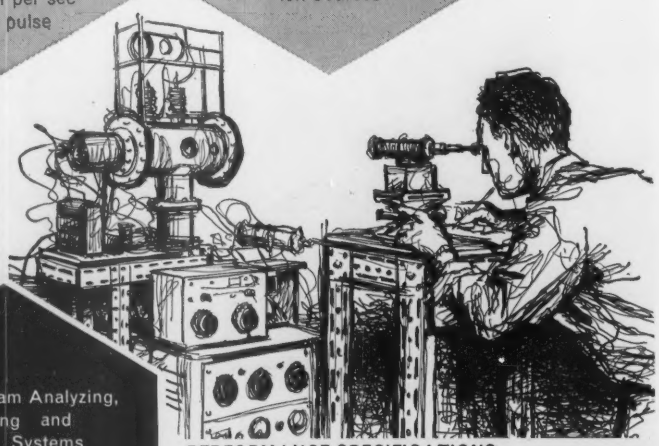

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The Human Study of Human Beings

The growth of importance of the study of human behavior raises a host of new ethical problems, at the head of which I would place the need for consent to the research by both observer and subject. Studies of the behavior of animals other than man introduced a double set of problems: how to control the tendency of the human observer to anthropomorphize, and so distort his observations, and how to protect both the animal and the experimenter from the effects of cruelty. In debates on the issue of cruelty it is usually recognized that callousness toward a living thing may produce suffering in the experimental subject, but it is less often recognized that it may produce moral deterioration in the experimenter.

Further problems arise when living human beings are studied in their natural habitats, in laboratories, or in partially simulated situations. The observer or experimenter must control his individual and cultural bias at the same time that he uses his membership in the species and in a culture as tools of research. He must systematically allow for the effect of his research methods on the behavior he is observing. He must protect his subjects from damage during and subsequent to his investigations. He must protect his particular scientific discipline and science in general from any loss of confidence that might make future scientific work more difficult. *And* he must protect from ill effects other human beings who are not involved in his particular set of observations.

The first two of these ethical and scientific imperatives are reasonably well understood, although many natural scientists may not be fully conversant with the various disciplined ways in which individual and cultural bias are allowed for—through, for example, allowance for countertransference in psychiatry or the employment of different observational methods with comparison groups. One possibility for dealing with the third imperative was discussed in *Science* [**132**, 989 (1960)], but much more specific safeguards are needed to protect the subjects of research, sometimes in terms of their own identity, sometimes in terms of their capacity to trust themselves or to trust other individuals of higher status. In regard to loss of confidence, there is a general recognition that a social investigator should not infuriate the local citizenry or outrage the board of trustees of a university by his research methods or the way in which he presents his results.

But the last requirement is one on which scientists have not yet adequately come to terms. The question can be stated simply: Is it scientifically and ethically permissible to deceive the subjects of research by disguising oneself as a "participant observer," or by introducing stooges into an experiment, or by making use of long-distance television or hidden microphones or other devices for concealed observation? When a human being is introduced who is consciously distorting his position, the material of the research is inevitably jeopardized, and the results always are put in question as the "participant"—introduced as a "psychotic" into a mental ward or as a "fanatic" into a flying-saucer cult group—gives his subjects false clues of a nonverbal nature and produces distortions which cannot be traced in his results. Concealed instruments of observation may not distort the subjects' course of action, but the subsequent revelation of their presence—as in the jury room that was tapped for sociological purposes—damages the trust both of the original participants and of all others who come to know about it. The deception violates the conventions of privacy and human dignity and casts scientists in the role of spies, intelligence agents, Peeping Toms, and versions of Big Brother. Furthermore, it damages science by cutting short attempts to construct methods of research that would responsibly enhance, rather than destroy, human trust.—MARGARET MEAD, *American Museum of Natural History, New York.*

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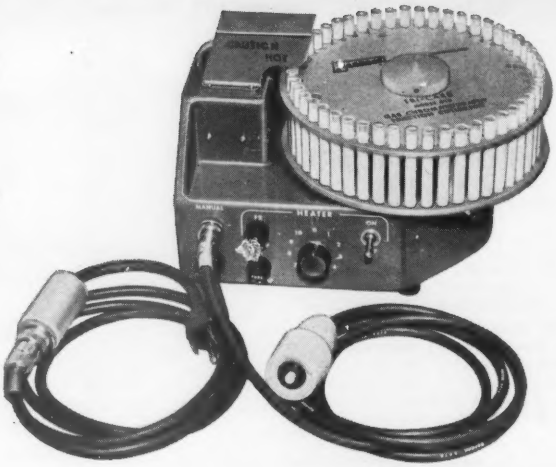

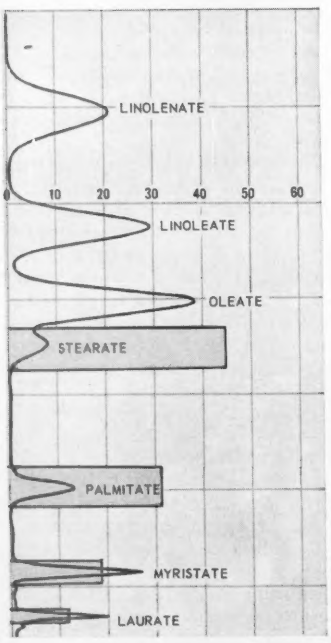

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CURRENT PROBLEMS IN RESEARCH

Attentive, Affective, and Adaptive Behavior in the Cat

Sensory deprivation of the forebrain by lesions in the brain stem results in striking behavioral abnormalities.

James M. Sprague, William W. Chambers, Eliot Stellar

This is the first report of an investigation of the effects of mesencephalic brain stem lesions on the behavior of cats. Much interest has centered, in recent years, around brain stem structures and their potential role in behavior. Particularly important in current thinking is the fundamental work of Magoun and his colleagues on the central core of the brain stem, the multineuronal, reticular formation, which receives afferent supply from all sensory systems and contributes significantly to the activation of the cortex and other forebrain structures (*1, 2*). This system, including the nonspecific thalamus, has also been implicated in the neural mechanisms for emotion, motivation, learning, and perception and even in consciousness and the integration of the highest functions of man (*3, 4*).

The lateral regions of the mesencephalic brain stem, containing the specific, highly localized, long and direct sensory pathways, have been thought by many to be restricted to the function of bearing specific information to the reticular formation and forebrain structures. Much of current neurophysiological theory does not take adequate account of other functions for these specific systems, despite the behavioral evidence to indicate the great importance of specific and meaningful sensory information in many nonsensory, as well as sensory, functions of the organism. For example, consider the very great disrupting effects of sensory isolation experiments in man where intellectual blocking, emotional disturbances, and hallucinations are reported (*5*); the importance of early sensory experience in the development of normal perceptual and emotional capacities (*6–8*); the devastating effects of extensive peripheral deafferentations on locomotion (*9*), use of individual limbs (*10*), sexual behavior (*11*), and maze learning (*12*); and the importance of sensory stimulation in hunger, thirst, specific hungers, and gross bodily activity (*13*). In some of these cases it has been implied that it is the nonspecific, activating effects of the normal sensory stimulation, through the reticular formation, that are important in the maintenance of normal, integrated behavior (*3*). But there is, at present, little direct experimental information to support this or alternative viewpoints.

The work discussed here was undertaken in an effort to make a direct attack on the problem of the respective roles of the reticular formation and the sensory pathways in behavior. To date, 35 cats have been studied extensively, both preoperatively and after lesions had been made which damaged different portions and different amounts of mesencephalic brain stem, bilaterally and unilaterally. Because lateral lesions produced surprisingly extensive defects and provided a unique opportunity to assess the contribution of the reticular formation to behavioral functions after severance of the lemnisci, most of the cases reported here sustained lateral lesions in which the medial structures of the brain stem were spared.

Procedures

The assessment of behavior in this investigation was carried out by three major methods: reflex testing, situational testing, and formal psychological testing. Preoperatively, the cats were given careful *neurological examinations* on repeated occasions, over periods as long as 6 months. Evaluations were made of tactile, visual, abduction, and chin placing reflexes; hopping, supporting reactions, and postrotatory nystagmus; responses to touch, to painful stimuli on the head and body, and to hot and cold water on the extremities; and visual and auditory reflexes. The *situational tests* were standardized insofar as possible and included responses to dogs, mice, rats, monkeys, and other cats; brief exposures to extremes of heat and cold; responses to sexual stimulation, artificial or in coitus; reactions to food (its localization in space by smell or vision and its acceptance or rejection when powdered with quinine) and the acceptance or rejection of various nonfood objects; response to catnip ball, string, crackling paper; and reaction to a variety of noxious stimuli: ether, ammonia, electric shock, water spray, and paper boots or alligator clips on the extremities. The *formal psychological tests* consisted of learning to avoid a striped card accompanied by shock; classical leg-flexion and respiratory conditioning with shock as the unconditioned stimulus and with visual,

Dr. Sprague and Dr. Chambers are professors of anatomy, and Dr. Stellar is professor of physiological psychology in the Institute of Neurological Sciences and Department of Anatomy, School of Medicine, University of Pennsylvania, Philadelphia.

tactile, and auditory conditioned stimuli; avoidance conditioning in the shuttle box with visual and auditory signals; learning a simple instrumental response to obtain food; and position, black-white, and pattern discrimination for food rewards.

Lesions were made stereotaxically with electrolytic currents; the atlas of Jasper and Ajmone-Marsan (*14*) was followed. After operation, the cats were studied for up to 2½ years. They were reexamined periodically throughout the postoperative period in reflex tests, in the situational tests, and in the formal psychological tests. Brain waves were studied in a number of cases; a few animals were stimulated through implanted electrodes; and as a terminal procedure in several cases, evoked-potential maps were made of the somesthetic areas of the cerebral cortex. In the end, all animals were perfused and their brains were fixed, sectioned, and stained with Nissl and Weil stains in alternate sections. The lesions were studied histologically and reconstructed. In addition, animals were prepared for Nauta stain, after lesions had been made in the lemnisci and in other areas, both cortical and subcortical, in order to gain information on afferent and efferent projections to the midbrain area involved in the lesions.

Results

The major findings reported here relate to the animals prepared with lesions of the lateral brain stem, involving the classical, long lemniscal pathways (Figs. 1 and 2). These animals showed many marked symptoms. Most of them can be described under three headings: (i) changes in sensory capacities, (ii) changes in affect or emotionality, and (iii) changes in adaptive responses to the environment, including other animals.

Changes in sensory capacity. Quite expectedly, all animals showed marked tactile, proprioceptive, nociceptive, auditory, and gustatory defects, for the known pathways (Fig. 1*A*) serving these modalities were interrupted in their central course (*15–18*). Quite unexpectedly, the animals also showed similar visual and olfactory defects, even though the known pathways in these systems were not directly involved in the lesions. The sensory defects were perhaps best seen in the cats with unilateral lesions, on the side of the body contralateral to the lesions, for easy comparison could be made with the unaffected, ipsilateral side. Tactile and visual placing were absent or greatly reduced in the contralateral limbs; hopping was often impaired, and it was possible to place the contralateral foreleg in a contorted position over the back without inducing the prompt struggling and adjustment that the animal made when its ipsilateral foreleg was treated in similar fashion. When the animals were held with the legs pendant, the contralateral limbs were extended and immobile whereas the ipsilateral were flexed and actively searching in space. The animals fended off the examiner's hands with the ipsilateral forelegs. In chin placing, only the ipsilateral legs were placed typically, or the contralateral leg would come up very slowly and later than the ipsilateral. Response to touch or painful stimulation on the contralateral side resulted in poor activation and little or no localization of the site of stimulation; in fact, when localization occurred, it was usually to a comparable point on the opposite side of the body.

Smell and vision were similarly defective on the side opposite the lesion. When fresh meat was presented on the ipsilateral side, the hungry cat would sniff and bat at it with its paw. When the meat was passed to the contralateral side, however, sniffing ceased and there was no sign of orientation toward it. This difference between the two sides occurred when both of the cat's eyes were masked—a finding that showed

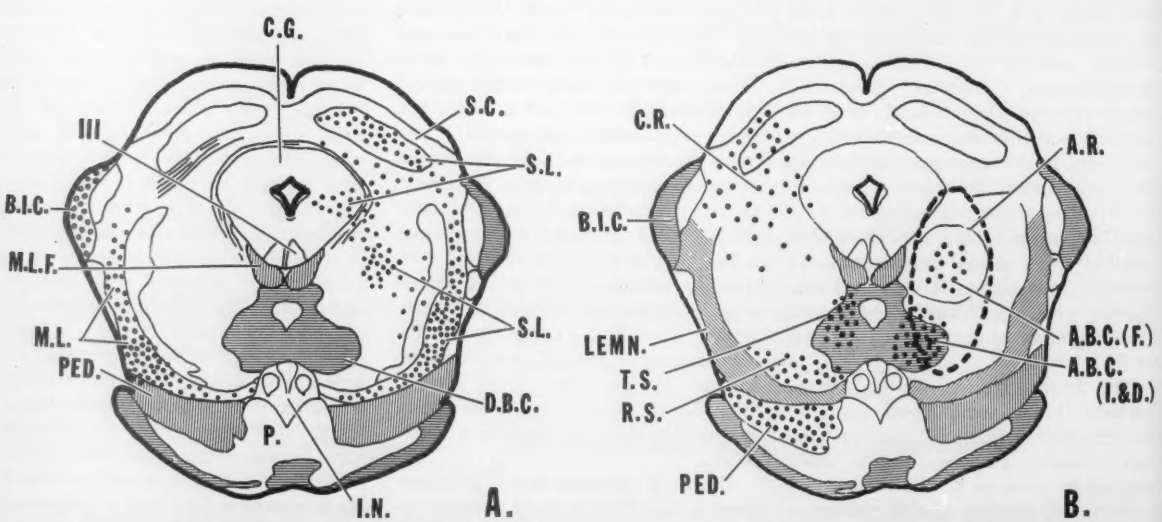

Fig. 1. Midbrain of the cat, at the level of the lesions, showing the position of the long ascending and descending pathways, based on anatomical and physiological studies. *A*; Ascending lemniscal tracts (see *15–18*); *B*; ascending cerebellar (*46*) and reticular (*17, 47*) paths and descending corticoreticular (*16*), tectospinal (*20*), and rubrospinal (*17*) tracts and descending cortical paths in the basis pedunculi (*16*); *A.B.C.(F)*, ascending cerebellar path from fastigial nucleus; *A.B.C.(I. & D.)*, ascending cerebellar path from interpositus and dentate nuclei; *A.R.*, ascending reticular paths outlined by broken line with central focus shown by solid line; *B.I.C.*, brachium of inferior colliculus (auditory); *C.G.*, central gray matter; *C.R.*, corticoreticular path; *D.B.C.*, decussation of brachium conjunctivum (cerebellum); *I.N.*, interpeduncular nucleus; *LEMN.*, lemniscal paths; *M.L.*, medial lemniscus; *M.L.F.*, medial longitudinal fascicle; *P*, pons; *PED.*, basis pedunculi; *R.S.*, rubrospinal path; *S.C.*, superior colliculus; *S.L.*, spinal lemniscus (spinothalamic, spinotectal, spinoreticular); *T.S.*, tectospinal path; *III*, oculomotor nucleus.

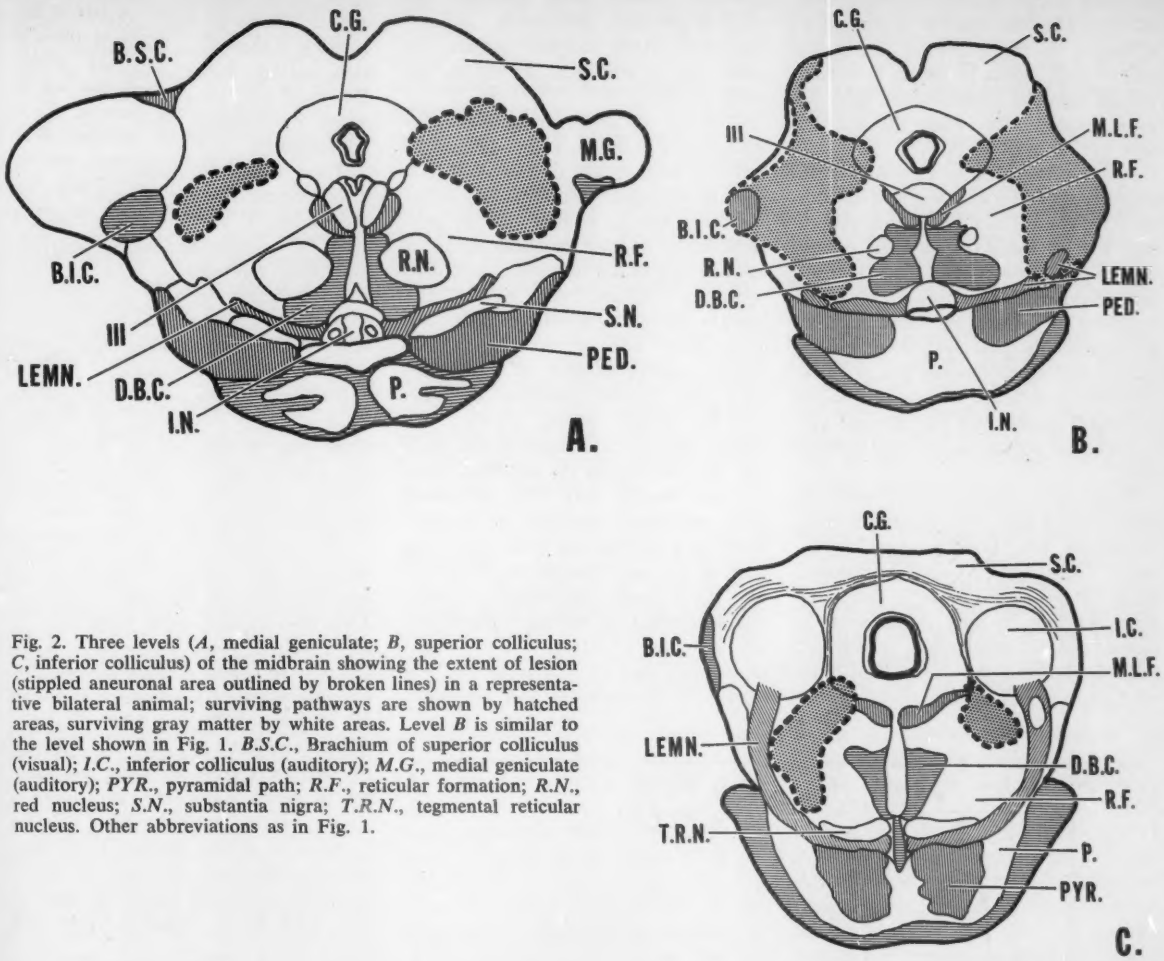

Fig. 2. Three levels (*A*, medial geniculate; *B*, superior colliculus; *C*, inferior colliculus) of the midbrain showing the extent of lesion (stippled aneuronal area outlined by broken lines) in a representative bilateral animal; surviving pathways are shown by hatched areas, surviving gray matter by white areas. Level *B* is similar to the level shown in Fig. 1. *B.S.C.*, Brachium of superior colliculus (visual); *I.C.*, inferior colliculus (auditory); *M.G.*, medial geniculate (auditory); *PYR.*, pyramidal path; *R.F.*, reticular formation; *R.N.*, red nucleus; *S.N.*, substantia nigra; *T.R.N.*, tegmental reticular nucleus. Other abbreviations as in Fig. 1.

the olfactory component of the deficit. Careful testing with first one eye masked and then the other showed a failure to respond in the large (70- to 90-percent), temporal visual field on the contralateral side. Within the smaller (10- to 30-percent), nasal visual field on that side, response to fresh meat was actually quite normal and accurate even though the meat was held out far enough to minimize olfaction (20 to 30 inches). The ipsilateral eye turned out to be deficient in the nasal field and normal in the temporal field.

Despite these marked sensory defects, it was possible to demonstrate responsiveness, on the contralateral side, to visual, tactile, and auditory stimulation by prolonged and intensive training. It appeared from these and other data that the defect here was not so much a simple sensory deficit as it was a failure in the capacity to utilize sensory information in making adaptive responses to the environment, in attending to relevant stimuli, and in localizing stimuli in space or on the body surface. For example, it was very difficult to develop a conditioned flexion response in the foreleg contralateral to the lesion, and when a response did occur, it was usually not a discrete response but a generalized one involving both forelegs. In one extreme case, tactile stimulation of the contralateral leg failed completely, over many hundreds of trials, to yield a conditioned flexion response in that leg (Fig. 3). Yet the animal was responsive to touch on that leg, for the conditioned tactile stimulus elicited a respiratory conditioned response and, early in training, a flexion response in the previously trained, opposite leg. Furthermore, it was possible to train the animal to orient its head to touch on the contralateral leg by feeding it repeatedly near the point touched. After this additional training, discrete conditioned flexion responses were frequently obtained in the contralateral leg, but only when the animal oriented or attended to this leg. If attention was not directed to the leg in this way, the animal did not give conditioned flexion responses. Thus, it appeared that the failure of this animal with a unilateral lemniscal lesion was primarily in attention rather than in sensory capacity as such. It is interesting to note in this connection that conditioned responses were also elicited in the contralateral leg when the tactile conditioned stimulus was paired with subthreshold stimulation of the opposite motor cortex through an implanted electrode.

In situational tests, the cats seemed to fail to appreciate the significance of a mouse or an aggressive dog or cat on the contralateral side and thus re-

sponded inappropriately to these stimuli. For example, the cat in pursuit of a mouse on the ipsilateral side would lose it and appear to forget it when it passed into the contralateral field. Or more dramatically, while the cat that was attacked by a dog on the unaffected, ipsilateral side showed normal defensive reactions, it was not uncommon for the cat to turn its contralateral side toward the dog and then remain in that position without defense or emotion. Similarly, there was little or no response to threatening movements of the examiner's hand toward the contralateral eye; when the tail was pinched, the animals attacked objects held in the ipsilateral visual field like normal cats but ignored objects in the contralateral field.

These same deficits were seen on both sides in cats with bilateral lemniscal lesions. They failed to show any defense and showed only occasional, weak escape reactions to a dog; they were deficient in their reactions to a mouse and in localization, if any, of painful clips on the body, and they were grossly deficient in many of the reflexes tested. Such animals also showed gustatory deficiencies, for early in recovery they accepted and ate nonfood objects and meat soaked in quinine powder.

Changes in affect or emotionality. In addition to these sensory defects, the animals with bilateral lesions showed greatly changed emotional responses. We have already pointed out the great deficiencies in their reactions to an attacking dog or cat and their limited response to a mouse. While painful stimulation elicited generalized struggling, it produced none of the visible autonomic accompaniment of emotion—very few typical affective responses such as hissing, spitting, clawing, and biting; what little struggling did occur did not long outlast the stimulus. These animals showed very little autonomic and emotional response to electric shock in a shuttle box even though the current was high enough to be tetanizing. They could be slapped, shaken, and suspended by one leg without protest, defense, or attack. On two occasions when this kind of treatment was carried to the extreme and prolonged over many minutes, explosive autonomic discharge was seen, including panting, piloerection, defecation, urination, batting, and clawing all at once. But even this massive response terminated immediately upon cessation of stimulation.

These cats with bilateral lesions were also deficient in their response to noxious fumes. It was possible to etherize them with only the mildest restraint, and they tolerated a cone saturated with ammonia without protest, even though they sneezed and lacrimated. Also, the females in heat were grossly deficient in sexual responses. Artificial vaginal stimulation would cause tail deflection, rump elevation, and treading; there was sniffing but no estrual cry and only a limited after-reaction, and during stimulation the head could be engaged in other activities.

Thus, the cats with bilateral lesions showed a great change from their preoperative style of affective responding. Two animals that were intractably vicious before operation became docile and easy to handle postoperatively. Preoperatively friendly and affectionate cats did not solicit affection postoperatively, did not respond to it, and rarely purred. All cats were typically mute and lacking in facial expression, presenting a blank, staring, masklike look. Almost all sense of danger seemed to be lost, and in some cases the animals would repeatedly approach attacking dogs or cats, only to be rebuffed again and again.

Changes in adaptive response. In addition to maladaptive lack of emotional behavior these cats showed adaptive falures in other ways. In the early postoperative period they became hyperactive, walking incessantly, usually about the periphery of a room. Actually this appeared to be hyperexploratory activity rather than random hyperactivity per se, for the head and eyes made constant searching movements and the cats would stop periodically at objects and sniff repeatedly, only to go on to the next place and sniff again. Never was it possible to find any stimulus that could have set off the searching behavior, and never could an adequate olfactory stimulus be found, nor were the points sniffed ones that attracted normal cats. The hyperexploratory behavior was markedly stereotyped; the same ground was gone over again and again, and it was difficult to distract the cats from this activity. However, putting out the lights or placing the cat in

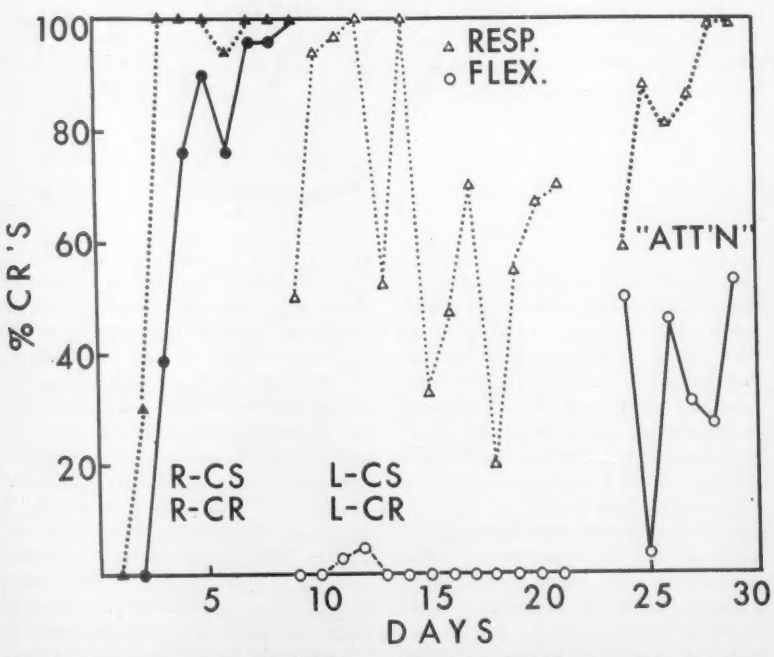

Fig. 3. Course of respiratory (dotted line) and leg-flexion (solid line) conditioned reflexes (*CR*) to a tactile stimulus (*CS*) in a cat with a large right, unilateral lemniscal lesion. Note the rapid acquisition and stability of the conditioned responses when the normal, right foreleg was used (*R–CS, R–CR*). When the affected, left foreleg was subsequently used (*L–CS, L–CR*), flexion conditioned reflexes were virtually absent and respiratory conditioned reflexes were unstable. Note the improvement in both conditioned responses when the animal was trained to attend (*"ATT'N"*) the tactile stimulation of the left leg; the dip in the curve on day 25 occurred because attention was directed to the food cup instead of the leg.

a small box or cage or in a strange room would usually dampen this activity.

When confined to a cage or small box the animals spent a great deal of time licking and biting at hair and skin on selected parts of their bodies, usually the middle of the lower back. They did not groom normally or keep clean, but it was easy to prevent skin irritations by frequent brushing or powdering. One animal licked and sucked the tip of its tail incessantly until all the skin was removed and the muscles and tendons were exposed.

Both male and female animals also exhibited a curious mounting of other animals, usually approaching from the side, seizing them on the back of the neck with the teeth, and then rolling over. This was incomplete as a sexual response and was not a really typical playful response; it was repeated over and over with vigor on male and female cats even after severe rebuffs, was usually directed toward the most actively moving cat in the room, and was also directed toward a dog, a monkey, and a rat. A catnip ball elicited a similar response from these animals; a cat would seize it and hold it in its mouth, and the ball could be removed only by forcibly prying the cat's jaws apart; sometimes the animal held it for several hours, and occasionally part of the response was to push the ball between the hind legs in a kind of mounting action. Also similar was the way in which these cats would hold a dead mouse in the mouth for long periods; in such cases, the mouse would be eaten only if cut up in small pieces.

Eating was also affected in these animals. Soon after the operation they would not eat voluntarily, but a touch of the lips evoked brisk snapping and swallowing. Such eating apparently did not produce satiation and was indiscriminate, for the cats would also seize and swallow nonfood objects such as orange skin, wood shavings, and cigarettes. One cat behaved in this way for over a year postoperatively and never ate normally. Others resumed voluntary eating but always ate voraciously and in abnormally large quantities, so that they eventually became somewhat obese.

The abnormal adaptation of these animals also was apparent in simple learning situations. Typically, these cats worked well in the sense that they were highly motivated for food, were not disrupted by strong electric shock, and were not easily distracted. Yet many of them never mastered even simple problems at normal rates and often never reached high levels of performance even after prolonged training. Typically, their performance would wax and wane; sometimes they showed a considerable tendency to forget from one testing session to another, even though in some cases the tests were separated by only 2 hours. Errors would not disturb them, and unlike normal cats they would go on for many trials at chance levels of success, for example, and continue to work without reduction in vigor of running and without the refusal to eat and the licking, grooming, and balking (displacement) so often seen in normal animals when they make frequent errors.

Discussion

Quite clearly, lesions in the lateral or lemniscal region of the mesencephalic brain stem result in an extensive and consistent syndrome of symptoms. Animals with large bilateral lesions show marked tactile, auditory, proprioceptive, nociceptive, and gustatory as well as visual and olfactory defects. Such animals are typically mute and lack facial expression. They are almost completely without affect, showing on the one hand little sense of danger and only minimal aversive reactions and on the other hand no pleasurable responses to petting or sexual stimulation and no solicitation of either, unless the mounting behavior can be considered as such. Aggression and rage are almost completely absent, as measured by somatic and autonomic responses, although temperature regulation is only slightly impaired. Much of their waking activity consists of aimless, stereotyped wandering—an apparent visual and olfactory searching, hallucinatory in nature and very difficult to break into.

In summary, the sensory inattention, the lack of affect, and the ceaseless hyperexploratory behavior result in a great reduction in the richness and variability of behavior and give these animals an automaton-like character. Preoperative individual differences in behavior are largely wiped out; on most occasions the animals are out of contact with the external environment and their behavior seems internally or centrally directed and grossly inadequate in its adaptive value. Yet they are awake, active, and essentially normal in their basic motor capacities, and their electroencephalograms are similar to those reported by Magoun and his co-workers in their studies of lateral lesions (*19*).

Because the lesions in our studies are chiefly lateral, involving the lemniscal or specific sensory pathways, it is important to try to understand the symptoms in terms of sensory deprivation, particularly of forebrain structures. To begin with, it is easy to understand the interference with normal tactile, proprioceptive, nociceptive, auditory, and gustatory functions in terms of direct severance of the sensory projection pathways, as defined by anatomical and physiological studies (Fig. 1). The survival of functions in these modalities may be ascribed to (i) intact reflex mechanisms below the level of the lesion, (ii) routes to the thalamus and cortex through the reticular formation, or (iii) incomplete lemniscal section, particularly of the trigeminal portion, much of which lies scattered in the reticular formation.

The visual and olfactory defects are more difficult to understand than those in the other modalities, for there is virtually no involvement of the known afferent visual and olfactory pathways. These deficits may be due to (i) the involvement of unknown pathways in these sensory systems, (ii) the deleterious effects on vision and olfaction of so much specific sensory deprivation in other modalities, and (iii) (an alternative to the sensory deprivation hypothesis), the interruption of descending paths from the forebrain into the brain stem in the region of the lesions (Fig. 1*B*).

Let us consider the visual defects first. We know from control lesions, where no current was passed, that damage from electrode tracks going through the visual cortex, optic radiations, and superior colliculi was without effect. In lesions where current was passed, the superior colliculi were spared from major damage although the lesions severed many of the efferent paths (tectobulbar, tectospinal) as they leave the colliculus (*20*). In all cats showing visual symptoms, however, the destruction of the lemniscal systems was accompanied by undercutting of the superior colliculi (see the extension of the lesion into the central gray matter in Fig. 2*B*). One cat with a large lemniscal lesion largely escaped undercutting of the colliculi, and this animal was free of visual symptoms although it showed all

the others. Furthermore, three cats in which the colliculi were undercut in the absence of major lemniscal lesions showed mild visual defects (Fig. 4). It seems, then, that appearance of the full range of visual symptoms in our test animals was dependent upon damage to *both* the lemnisci and the area under the superior colliculi.

Although Blake (*21*) has reported some visual defects after large lesions of the superior colliculi were made in the cat, Myers (in the cat) (*22*) and Porter (in the chimpanzee) (*23*) found visual symptoms only when the area just beneath the superior colliculi was destroyed. In evaluating this area beneath the superior colliculi, it is of interest to note that, after illumination of the retina, evoked potentials can be recorded from the subcollicular area and central gray matter (long latency) as well as from the colliculi themselves (short latency) (*24*). This subcollicular area, however, does not show terminal degeneration in the cat after removal of the eyes or visual cortex, so the pathways shown physiologically from these structures must be indirect (*18, 25*). However, the subcollicular area receives direct projections from association cortex (Fig. 1*B*) (suprasylvian and anterior lateral gyri) and sensorimotor, sigmoid, and anterior ectosylvian cortex (*16*). It is also relevant to note that in the monkey (*26*) there are projections to the area beneath the superior colliculi from certain cortical association areas whose ablation produces visual deficits—parietal (*27*) and temporal (*27, 28*).

Another very intriguing possibility for the interpretation of the visual symptoms comes from the work of Arden and Söderberg (*29*), who found that the resting electrical activity in the lateral geniculate, after removal of the eyes, was dependent upon the integrity of the upper midbrain at the level of the lesions. The visual symptoms of our animals, together with the above evidence, strongly suggest that normal visual functions may depend upon the integrity of a midbrain mechanism receiving projections from the lemnisci, ascending reticular pathways, and cortical as well as subcortical areas.

The olfactory defects are even more puzzling than the visual because the primary olfactory paths are even farther from the site of the lesions. It is known, however, that olfactory sensitivity is greatly reduced by elimination of the sympathetic outflow to the olfactory mucosa (*30*). Since our test animals have such poor autonomic activity, it is possible that their olfactory impairment can be understood in terms of such reduced sympathetic output. It is also suggestive that the electrical activity of the olfactory bulb is influenced by the activation of other sensory systems (*31*), but as yet we have made no effort to study the electrical activity of the olfactory system.

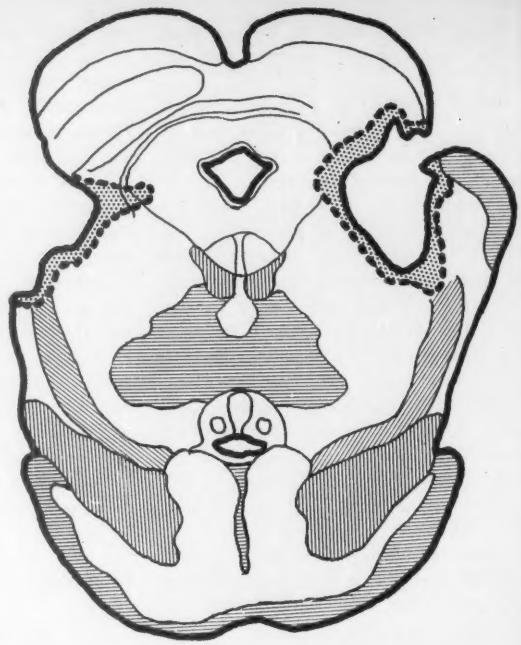

Fig. 4. Midbrain of one of three cats, with minimal visual symptoms, showing destruction of the dorsolateral tegmental area below the superior colliculus, the lemnisci being largely spared. Structures shown as in Figs. 1 and 2.

Something of the general character of the sensory defects in our test animals may be understood if one considers that the animals may be generally aroused by strong stimuli in all modalities but fail in localization of and attention to stimuli. On the one hand, this constitutes behavioral evidence to show that the reticular pathways that survive after lemniscal lesions are capable of only diffuse arousal, as data from electroencephalographic recordings suggest (*1, 19*). On the other hand, the sensory inattention and poor localization are remarkably reminiscent of the effects of posterior parietal cortex lesions in primates, including man. Like the primate with unilateral lesions in the parietal lobe, our cats with unilateral lesions ignore all events on the side of the body contralateral to the lesion, regardless of modality, yet they show some signs of receiving all stimuli on this side. Particularly striking is the case of simultaneous bilateral stimulation of corresponding receptive points, where "rivalry" heightens the inattention on the affected side. It is as though the lemniscal lesions, at the midbrain level, were impairing cortical function by removing the possibility of patterned afferent input to cortical structure.

It is also possible to look at the great reduction in affect of our animals as a consequence of the sensory deprivation produced by lemniscal lesions. The failure of our animals to show emotional or autonomic responses may, in part, be a failure to attend sensory events in the environment, a failure to localize dangers and threats, a failure to make sustained and adaptive reactions to stimuli—in short, a failure to "appreciate" the significance of sensory stimuli. That sensory deprivation per se may produce such changes in affect is shown by Melzack's finding (*8*) that dogs reared in sensory isolation are grossly deficient in their emotional and adaptive reactions to noxious stimulation and in their ability to learn avoidance responses in simple training situations.

The peculiar, stereotyped, hyperexploratory behavior of these test animals also makes some sense in terms of sensory deprivation. Here it is of interest to note that human beings who have been subjected to sensory isolation frequently suffer hallucinations and sensory "hunger" (*5*). The searching behavior of our cats seemed to have a hallucinatory quality, for no eliciting

stimuli could ever be found. It is as though their behavior were centrally determined, for it was stereotyped and ceaseless, unaffected by the sensory events that normally stop and start the behavior of cats. In fact, it sometimes appeared as though the cats, like the isolated human beings and dogs, were "seeking" out stimulation as a result of their sensory deprivation. Their endless wandering not only could provide proprioceptive feedback through surviving medial pathways (*32*) but also would increase the possibilities of visual and olfactory stimulation. In the dark, the wandering ceased. In a cage or small box, the hyperactive locomotion also stopped, but it was replaced by endless licking and chewing of hair and skin on the back and by overeating, if food was present.

Both the hyperexploratory activity and the increased licking might also be interpreted as "release" phenomena, as though some inhibitory influence had been removed. This same interpretation could also apply to the abnormally brisk snapping these animals show when their lips are brushed, to their seizing of other moving animals by the back of the neck, and to their clamping bite on the catnip ball. In all of these cases the behavior appears to be without affect and without any obvious adaptive end. Thus the cat with midbrain lesions does not seek out the moving animal but simply responds when stimulated by it; when rebuffed, it "explores" the room until stimulated by the moving cat again.

While any parallelism is purely speculative, it is worth noting here that the behavior of our cats with midbrain lesions bears striking resemblance to the behavior of certain autistic children. These children are very inattentive and may be unresponsive to many forms of sensory stimulation. They are typically flat in their affect and often have little facial expression. And they frequently walk or wander endlessly or engage in other highly repetitive, rhythmic activities from which it is almost impossible to distract them. Unfortunately, little is known of the neurological or psychological basis of this disorder, although it is often considered to be one form of early schizophrenia, related to deprivation of normal emotional experiences during development (*33*). This interpretation of autistic behavior, taken together with the effects of human isolation (*5*), the effects of early sensory deprivation in dogs (*8*) and monkeys (*6*), and the behavior of our cats with lemniscal lesions, suggests the importance of rich and varied sensory stimulation in the development and maintenance of attentive, affective, and adaptive behavior. The studies reported here suggest further that it is the specific, the patterned and localized, sensory information, carried to the forebrain via the lemnisci (*34*), that is essential.

It is clear from the above discussion that we believe the symptoms obtained from lateral lesions in the midbrain discussed in this article are due primarily to a sensory deprivation. The concept of sensory deprivation proposed here is not limited to the thalamic relay nuclei and their cortical receiving areas. Some of the defects of the animals with lemniscal lesions are similar to the classical signs following ablation of the cortical receiving areas (for example, the loss of tactile placing and searching and tactile localization). There are, in addition, some similarities between the symptoms of our test animals and symptoms that follow rhinencephalic lesions (*35*, *36*), but in general the two cases are quite different, for the cat with rhinencephalic lesion shows little sensory defect and may show exaggerated emotion and sexuality. Most significant, however, is the striking similarity of deficits in reflexes and affective behavior in the animal with lemniscal lesions and in the total neodecorticate, reported by Bard and Mountcastle (*35*). The similarities strongly suggest that the lemniscal lesion produces many of its effects through a deafferentation of the forebrain which greatly impairs normal neocortical function. The disruption in behavior produced by lemniscal lesions thus appears to be due more to a sensory deprivation of the neocortex than of the rhinencephalon; were both regions equally affected, one might expect in the cat with lemniscal lesions the sham rage that is seen in the cat which lacks both cortex and rhinencephalon. If these suppositions are correct, there should be a significant change in the affect of the animal with lemniscal lesions after a subsequent removal of the rhinencephalon unless the lemniscal lesions have impaired the midbrain mechanism for rage.

The sensory deprivation of the forebrain that follows lemniscal lesions is extensive, for the lemniscal paths terminate widely in many of the nonspecific as well as in the specific thalamic nuclei, supplying sensory, motor, and associational cortex and many subcortical structures. These severed paths also terminate directly in the subthalamus, and in the tectum and tegmentum of the rostral midbrain. Therefore, by severance of the lemniscal projections, the lesions in our test animals impaired the function of subcortical as well as cortical structures. One specific example of the possible effects of direct deafferentation of subcortical structures is seen in the deficit in faciovocal activities produced by lemniscal lesions. These same effects have previously been reported after direct destruction of the central gray matter and adjacent tegmentum (*37*). Since there was only minimal involvement of the central gray matter in the lesions in our test animals (Figs. 2 and 4) and since stimulation of the lemniscal paths (Fig. *1A*) evokes faciovocal activity (*38*), the faciovocal deficits in these animals may be due in large part to deprivation of afferent input into the central gray matter and tegmentum via the lemniscal pathways.

Finally, it should be noted that among other structures that are partially deafferented by lesion of the lemnisci (or actually invaded by the lesion) is the reticular formation of the rostral midbrain. We have already pointed out that the lesions in our test animals extended into the dorsolateral tegmentum beneath the superior colliculi. This limited area seems to be involved in visual function and is the site of interaction of many ascending and descending pathways, including the medial parts of spinal (*15*, *17*, *39*) and trigeminal lemnisci (*17*, *40*), ascending reticular paths (*17*), descending subthalamic and pallidal paths (*41*), and corticifugal paths (*16*, *42*). In trying to assess the role of the dorsolateral area of the reticular formation in the symptoms noted it should be remembered that lesions largely restricted to this area produced only mild, partial defects (Fig. 4). This finding, taken together with the fact that a large part of the reticular formation is intact and is fully innervated below the lesion, leads us to believe that the symptoms in our test animals are not primarily due to reticular involvement.

In support of this conclusion is the additional finding that large lesions of the midbrain reticular formation produce results different from those described here (see also *43*). One animal with a lesion in the lateral part of the

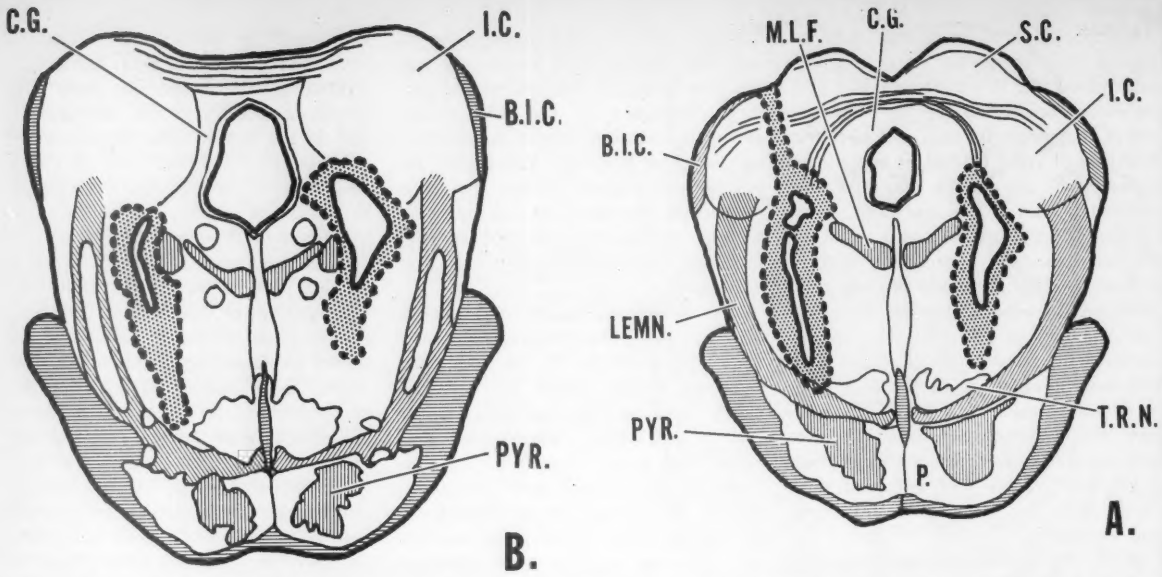

Fig. 5. Two levels of the midbrain of a cat, showing lesions in the lateral part of the reticular formation. Abbreviations as in Figs. 1 and 2. The extent of the lesions is shown by heavy, broken lines; included is a stippled aneuronal area surrounding a cavity.

reticular formation which largely spared the adjacent lemnisci (Fig. 5) was asymptomatic. In a second case, a cat with an extensive and more medial lesion of the reticular formation (Fig. 6) showed no sensory deficits. The animal was somnolent for over a week, with synchronized electroencephalograms (*19*), and remained catatonic and sluggish for over a month. After recovery from this phase, the cat tended to be drowsy when undisturbed, but it was easily aroused to alert wakefulness and reacted appropriately to various situations (dog, mouse, food, other cats, home cage, and so on). This cat was hyperexcitable and showed well-organized and well-localized affective reactions (hissing, batting, clawing, growling, piloerection, pupillary dilatation) in response to painful stimuli or to any sudden visual, auditory, vibratory, or tactile stimulus, even though mild in intensity (see *44*). Because its threshold for emotional response was so low, this cat was also highly distractible in contrast to normal cats and, particularly, in contrast to the animals with lateral lesions. Possibly because of this and the accompanying hypokinesia, the animal performed poorly in formal learning tests.

Thus, it appears that after interruption of much of the classical, lemniscal paths at the rostral midbrain, the cat shows generalized, largely unadaptive and unlocalized arousal to even strong stimulation, with little attention and affect, despite the fact that the animal is wakeful and active and has good motor capacity. In contrast to this picture, a large reticular lesion sparing the lemnisci results in an animal whose general behavior is much like that of a normal cat except for chronic hypokinesia or drowsiness and for strong and easily aroused affect to mild stimulation. Certain formal conditioning procedures showed that animals with lesions of either type could learn to discriminate and make adaptive responses, although they differed greatly in their performance and were in all cases abnormal.

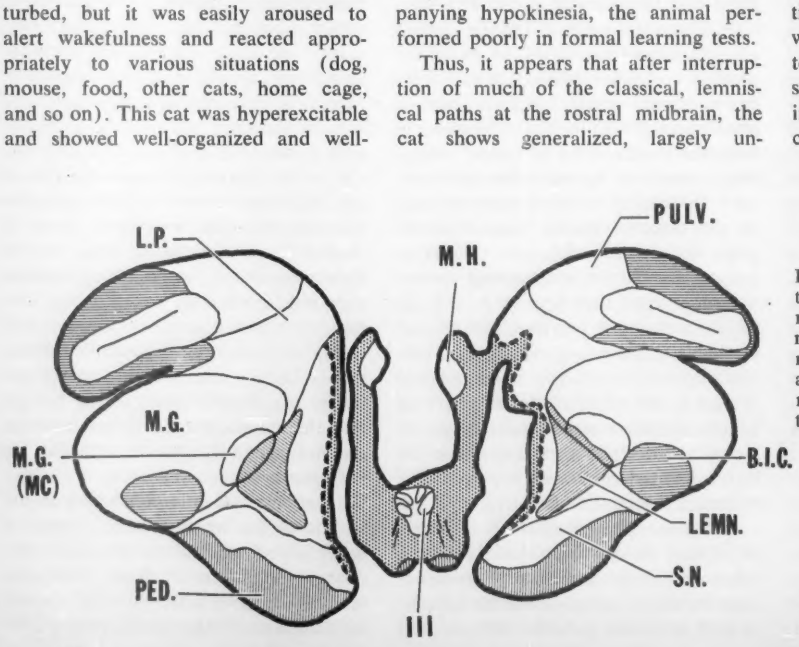

Fig. 6. Rostral midbrain showing the extent of a lesion in the medial part of the reticular formation. *L.P.*, Lateral posterior nucleus of the thalamus; *M.G.(MC)*, magnocellular part of the medial geniculate nucleus; *M.H.*, medial habenular nucleus; *PULV.*, pulvinar. Other abbreviations as in Figs. 1 and 2.

Summary

Lesions of the lateral portion of the upper midbrain, involving medial, lateral, spinal, and trigeminal lemnisci primarily, result in a consistent syndrome of symptoms in the cat. (i) There is a marked *sensory deficit*, characterized mainly by sensory inattention and poor localization in the tactile, proprioceptive, auditory, gustatory, and nociceptive modalities, where direct pathways are interrupted. Similar defects appear in vision and olfaction where no known direct or primary paths are interrupted. (ii) These cats are characterized by a *lack of affect*, showing little or no defensive and aggressive reaction to noxious and aversive situations and no response to pleasurable stimulation or solicitation of affection or petting. The animals are mute, lack facial expression, and show minimal autonomic responses. (iii) They show a *hyperexploratory activity* characterized by incessant, stereotyped wandering, sniffing, and visual searching, as though hallucinating. This behavior appears to be centrally directed and is very difficult to interrupt with environmental stimuli. (iv) They also demonstrate *exaggerated oral activities*: they snap in response to tactile stimulation of the lips, seizing and swallowing small objects even if inedible; they overeat; they hold objects too large to swallow (a mouse, a catnip ball) firmly clamped in the mouth for long periods of time; they mount and seize other animals (rat, cat, dog, monkey) by the back or the neck; they lick and chew the hair and skin of the back or tail incessantly when confined in a cage.

In interpreting these results we emphasize the view that the syndrome is due chiefly to the extensive, specific, sensory deprivation produced by interruption of the lemnisci at the rostral midbrain. The relation of these findings to the effects of sensory isolation in man and animals, to the effects of midbrain lesions and neodecortication, to parietal lobe syndrome in primates, and to the behavior of autistic children is discussed. It is our belief, from these studies, that the symptoms produced by interruption of the lemnisci, characterized by a high degree of somatotopic and modality localization, are due to a loss of patterned sensory input to the forebrain, particularly to the neocortex and to the rostral midbrain. Without a patterned afferent input to the forebrain via the lemnisci, the remaining portions of the central nervous system, which include a virtually intact reticular formation, seem incapable of elaborating a large part of the animal's repertoire of adaptive behavior (*45*).

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Complexities of Perceived Brightness

Apparent brightness may increase, decrease, or remain constant as illumination is increased.

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It is quite generally recognized that if the amount of light falling on a given surface is doubled, and the intensity of the retinal light image is thereby doubled, the apparent brightness may be perceived to increase by an amount that is quite different from the twofold increase in stimulus luminance. The precise relation between perceived brightness and stimulus luminance has been extensively investigated by the various experimental procedures used to develop psychological scales of sensory attributes, and on the basis of such studies, perceived brightness has come to be described as a visual attribute that increases with the logarithm or with some power (less than 1.0) of the stimulus luminance (*1*). This psychophysical relation is of concern to psychophysicists, photometrists, colorimetrists, illuminating engineers, and scientists interested specifically in sensory mechanisms.

Others, especially psychologists, who are primarily concerned with the visual perception of real objects emphasize a different aspect of the problem of apparent brightness. They point to the relative constancy of apparent brightness of visually perceived objects that is found in spite of tremendous changes in the intensity of retinal (proximal) stimulation: White snow continues to look bright and black coal continues to look dark even through a range of illumination so great that the coal in the high illumination may actually reflect more light to the eye than does the snow at the low extreme of illumination. Consequently we find a second group of investigations concerned not with the precise manner in which brightness increases with luminance but, rather, with the degree to which perceived brightness remains independent of stimulus luminance—that is, with the problem of brightness constancy (*2*).

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Brightness Constancy

In experimental analyses of brightness constancy, brightness matches are usually made between a single test object viewed under various conditions of illumination and surround and a separate, continuously variable comparison, or matching, stimulus that is seen in a constant surround. Independent controls for test and surround stimulation may be provided, as in the classical experiments of Hess and Pretori (*3*) and those of Wallach (*4*), or test and surround may be varied together by a single control for the over-all level of field illumination. The results usually fall somewhere between two extremes: If a so-called "reduction screen" is used for viewing the test stimulus, so that only the focal area to be matched is visible in otherwise dark surroundings, apparent brightness increases with increase in illumination, and matching luminance is directly proportional to luminance of the test stimulus ("stimulus matches"); if, on the other hand, the reduction screen is removed and the total scene is made visible, brightness matches to the same focal area may then remain constant, or nearly so, in spite of increases in illumination of the over-all scene—that is, matching luminance remains constant and independent of test-stimulus luminance. This tendency away from stimulus matches and toward brightness constancy is sometimes described as a perceptual regression from the proximal stimulus toward the real object (*5*). Some investigators explain it by saying that perceived brightness is a judgment that is influenced both by the intensity of light stimulation reflected from the surface of the object to the retina and by a "correction factor" that takes into account the over-all level of illumination incident on the various objects in the visual field. This "correction factor" or "allowance for the illumination" presumably compensates for the changes in stimulus intensity, and the perception thus remains constant (*6*).

Another proposal that has been made to account for the tendency toward brightness constancy is the suggestion that perceived brightness is not a matter of interpretation, but a direct response controlled by the ratios of the various luminances in the total visual field rather than by the luminance of any given focal area (*4*). Since the reflectances (or transmittances) of all objects in the field remain constant, their luminance ratios relative to one another are also invariant as over-all scene illumination is increased, and consequently, in this view, the perceived brightnesses of the various objects in the field remain constant and independent of level of illumination.

A careful study of the earlier data suggests that neither the "interpretation" hypothesis nor the "constant-ratio" hypothesis can adequately explain the variety of brightness phenomena observed, and the experiments discussed below will make clear why this is so.

Table 1. Luminance matches to individual areas of the test pattern for three levels of over-all illumination. Mean luminance data and variability for three subjects.

Focal area of test pattern	Log photometric luminance (mlam) of focal area	Mean log luminance (mlam) of matching field
Center	0.18	1.47 ± 0.10
	0.47	1.61 ± 0.20
	1.28	1.78 ± 0.10
Right	0.08	1.37 ± 0.08
	0.37	1.44 ± 0.14
	1.18	1.61 ± 0.14
Upper	$\bar{1}$.78	1.08 ± 0.14
	0.07	1.18 ± 0.17
	0.88	1.37 ± 0.17
Left	$\bar{1}$.15	0.54 ± 0.10
	$\bar{1}$.44	0.45 ± 0.20
	0.26	0.55 ± 0.10
Lower	$\bar{2}$.74	0.25 ± 0.17
	$\bar{1}$.04	0.22 ± 0.20
	$\bar{1}$.85	$\bar{1}$.78 ± 0.33

Matching Apparent Luminances

In our experiments (*7*), a pattern of squares of different luminances (see Fig. 1) comprised the visual scene, and each square differed from its neighbor and from the background by a constant ratio. The maximal ratio of focal-area luminances within the test pattern was 27:1 for the brightest (center) to the darkest (lower) of the square areas. The test pattern was projected on a screen 110 centimeters from the subject's eyes. The limiting boundaries of the rectangular illuminated test field subtended visual angles of 11°50′ by 10°20′, and each side of the individual squares of the test pattern subtended a visual angle of 3°. The over-all level of illumination of this scene was varied in three steps through a range of 1.1 log units.

With the total pattern visible, the subject matched the apparent brightness of each square area within the pattern at each of the three levels of illumination. He made these matches by successive inspection, by looking first at the designated focal area of the test pattern on the screen located to his right and then at the matching field contained within a shielded cubicle directly in front of him. The matching field was an illuminated rectangle (1°45′ by 2°24′) of continuously variable luminance, located about 41 centimeters from his eyes and centered in an illuminated surround (tungsten illumination, 60 mlam) that subtended an angle of about 145° at the eyes. Matches to the individual focal areas were made in random sequence, and the over-all level of scene illumination was also randomized. Results were obtained for three subjects, each of whom repeated all matches in a second experimental session.

Results

The averaged results for the luminance matches for both sessions and for all subjects are presented in Table 1 and in Figs. 2 through 6. The means are geometric averages—that is, averages of the logarithm of the luminance values. Each of the figures contains the mean data (open circles) for a single focal area of the test pattern and shows the relation between the calibrated luminance of that area of the test pattern (plotted as the abscissa) and its apparent luminance as measured by the matching luminance (plotted as the ordinate). Each figure also shows the alternative relations to be expected if (i) apparent brightness were constant and independent of increase in luminance (the law of brightness constancy), or (ii) apparent brightness increased according to some invariant law with the luminance of the retinal image in the focal area (the law of retinal stimulus). Figures 2, 3, and 4, for the center, right, and upper squares, respectively, show that for these three areas apparent brightness increases with increase in stimulus luminance but the matching luminance increases at a rate that falls between the rates predicted by the stimulus law and the constancy law. On the other hand, the mean data for the left square, shown in Fig. 5, closely approximate the function predicted by the law of brightness constancy. Finally, for the lower (and the darkest) test area, Fig. 6 shows that the apparent-luminance matches fall below the luminances predicted by the stimulus law and the brightness constancy law. Here we have the paradoxical result that apparent brightness *decreases* as stimulus luminance is *increased*. Conservative skeptics who find the result of Fig. 6 difficult to accept are asked only to observe, say, a bottle of india ink or a standard telephone set under dim illumination and then note the increased blackness when the overhead lights are switched on.

The results contained in Figs. 2 through 6 make it clear that no single generalization concerning brightness constancy is applicable to all of the objects of different reflectances in any single visual scene or stimulus configuration. With a general increase in illumination, light objects may increase in apparent brightness, intermediate objects may remain constant in brightness, and dark objects may become still darker in appearance.

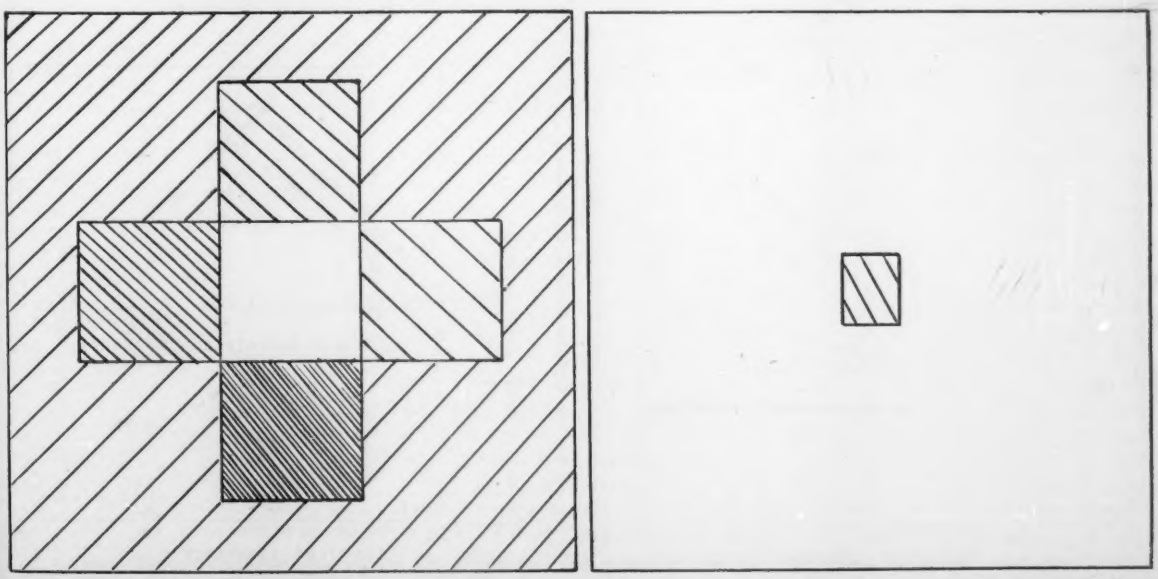


Fig. 1. Outline of test pattern (left) and matching field (right). Striations of test pattern are used in the figure only to illustrate density differences of different individual areas.

Findings versus Hypotheses

How do such results square with the explanations of brightness perception referred to above? If the experimentally determined luminance matches depart from the law of simple stimulus proportionality because the subject is applying a "correction" for level of illumination, then the data of Figs. 2–4 imply that he is systematically under-correcting, and consequently perceiving some increase in brightness with the general increase in illumination. The data of Fig. 5, however, imply, on such an analysis, that the subject's "correction" is nearly perfect: the apparent brightness shows almost perfect constancy as the level of illumination is increased. But if we use Fig. 6 as an index, the subject is presumably applying an overcorrection for illumination, since this area of the test pattern appears increasingly *darker* as the level of illumination is *increased*. When we remember that the subject is viewing a single test pattern, it hardly seems likely that he is applying a different correction for illumination to each of the different areas of the pattern. The concept obviously loses any usefulness it might have had as an explanatory principle once we recognize that the "illumination correction" would have to be multivalued for a single scene.

We run into similar difficulties with the hypothesis that invariant luminance ratios yield constant perceived brightnesses. The luminances of the various areas within the test pattern used in our experiments maintain invariant ratios with respect to one another as the illumination of the whole field is varied, and yet only one of the five areas remains constant in perceived brightness.

Thus, the two most frequently cited explanations for brightness constancy phenomena fail in this situation: Both

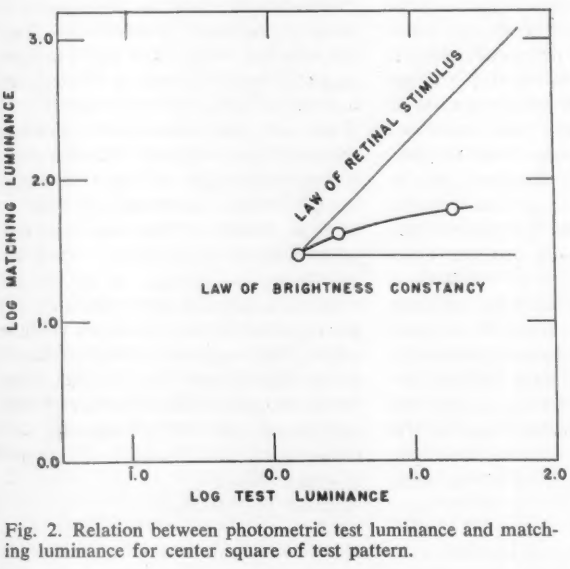


Fig. 2. Relation between photometric test luminance and matching luminance for center square of test pattern.

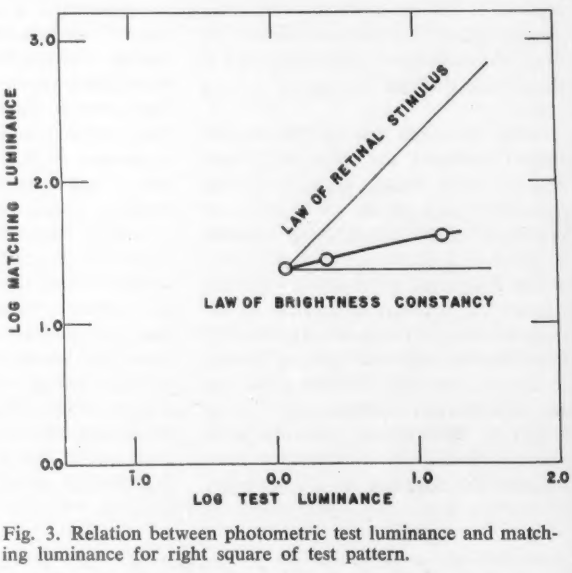


Fig. 3. Relation between photometric test luminance and matching luminance for right square of test pattern.

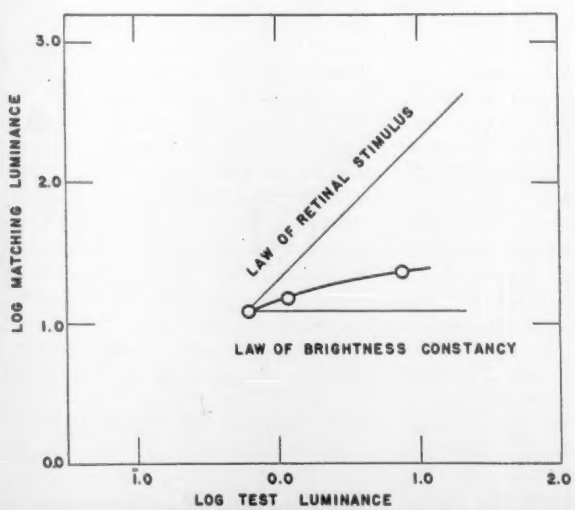


Fig. 4. Relation between photometric test luminance and matching luminance for upper square of test pattern.

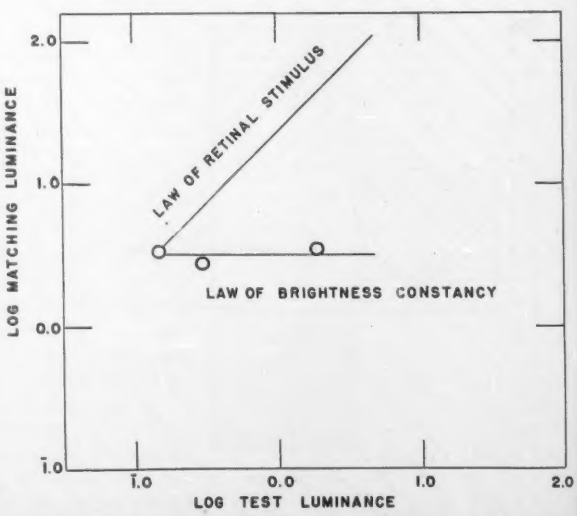


Fig. 5. Relation between photometric test luminance and matching luminance for left square of test pattern.

of these explanations require that all areas of the test pattern behave in the same way, and hence they do not account for the observed result that each individual area of the total scene shows its own characteristic and different dependence on stimulus luminance.

An important consequence of these characteristic variations can be seen from the combined data as plotted in Fig. 7. Here the graph shows the relation between the stimulus luminance and the apparent (matching) luminance for all five focal areas of the test pattern at each of the three levels of general illumination. Although the calibrated photometric gradient of this stimulus pattern is identical for all three levels, the *apparent* luminance gradient increases with increase in the level of over-all illumination. This effect is obvious from the figure if one simply compares the extent labeled R_1 (the range of apparent luminance for the lowest level) with that labeled R_3 (the corresponding range when the over-all level has been increased by 1.1 log units). The photometric range of stimulus luminance is constant at all three levels of illumination: log L_{max} minus log L_{min} equals 1.44. For the apparent luminance matches, however, log L_{max} minus log L_{min} at the lowest level of illumination is less than the photometric range and equal to 1.22; at the intermediate level it is equal to 1.39; and at the highest level of illumination the apparent range exceeds the photometric range and log L_{max} minus log L_{min} equals 2.00.

Table 2. Relation between luminance and magnitude of perceived brightness of matching field with constant, uniform luminance of the surround. Mean results for three subjects.

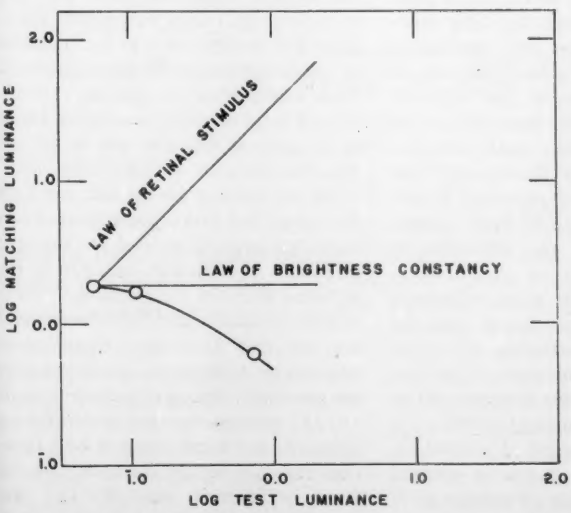
Log luminance (mlam)	Mean log brightness magnitude
$\bar{1}.07$	$\bar{2}.6332$
$\bar{1}.51$	$\bar{2}.8554$
$\bar{1}.94$	$\bar{1}.1662$
0.30	$\bar{1}.8554$
0.70	0.5366
1.09	1.2796
1.51	1.7835
1.89	2.0538
2.11	2.1844

Could these results simply be an artifact of the experimental conditions? Our yardstick for apparent luminance of the various areas of the test pattern is the matching luminance of the comparison field, and this field is itself seen in its own bright surround. We know that the relation between units of stimulus luminance and units of perceived brightness is not usually a simple one of direct proportionality. We also know that this relation is itself dependent upon the particular visual circumstances under which it is determined—that is, level of bright-adaptation, nature of surround illumination, and so forth (*8, 9*). Since our concern here is with apparent brightness per se, it becomes critical to determine directly the perceived brightnesses of the matching stimuli that were used to specify the apparent luminances of the various areas of the test pattern in these experiments.

Perceived Brightness and Luminance of Stimulus Field

Consequently, the relation between perceived brightness and the luminance of the matching stimulus field was determined, for the same three individuals who made the apparent luminance matches, by a method of subjective magnitude estimation. In this psychological scaling procedure, the apparent brightness of the illuminated surround (60 mlam), which remained constant, was assigned an arbitrary brightness magnitude value of 100. With this value for the surround as a standard of comparison, the subjects were required to assign estimates of numerical magnitude to the apparent brightness of the stimulus matching field as the luminance of this field was varied in a series of nine steps through a luminance range of three log units.

The geometric means ($n = 12$) of the magnitude estimates for the three individuals are given in Table 2, and the functional relation is plotted in logarithmic units in Fig. 8. The curve has been fitted by inspection to the plotted points representing the mean data obtained by the scaling procedure. The slope of the function is quite steep throughout most of the range, becoming less steep at the high levels where the stimulus luminance exceeds that of the surround, and also leveling off at the very low luminance levels at which an appearance of "maximal blackness" is approached.



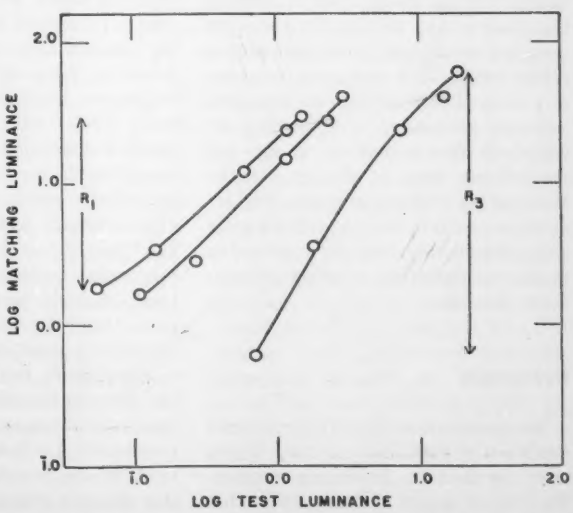
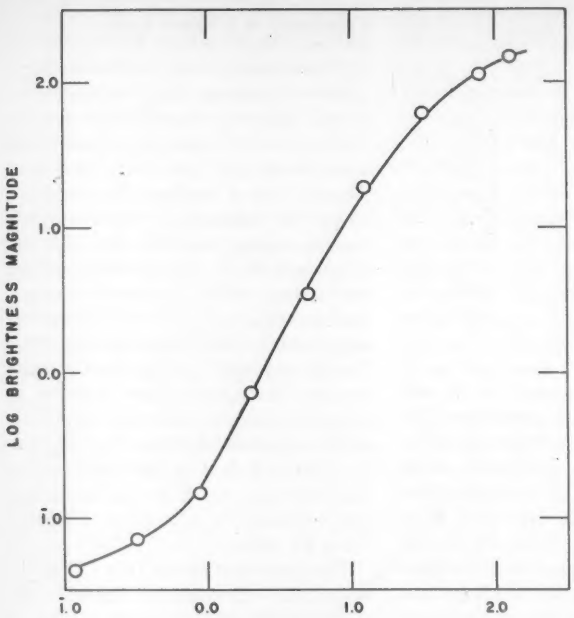


Fig. 6 (left). Relation between photometric test luminance and matching luminance for lower square of test pattern. Fig. 7 (right). Relation between photometric luminance gradient of test pattern and apparent (matching) luminance gradient for three levels of general illumination.



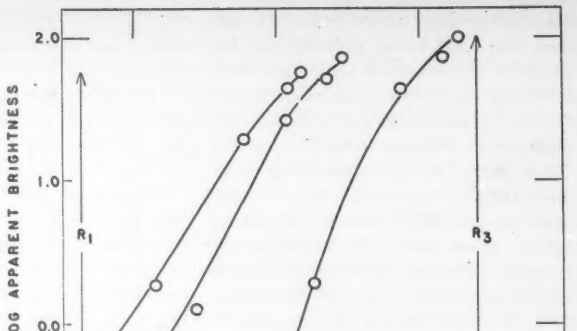


Fig. 8 (left). Relation between luminance of matching field and estimations of perceived brightness magnitude. Fig. 9 (right). Relation between photometric luminance gradient of test pattern and apparent brightness gradient for three levels of general illumination.

With the subjective magnitude function of Fig. 8, we now have the means at hand for "calibrating" in units of apparent brightness the luminance units of the matching experiments, and Fig. 9, based on this conversion, shows the relation between the apparent brightness gradient of the scene and the photometric luminance. Correlative with Fig. 7, the extent labeled R_1 represents the range of apparent brightness from the darkest to the brightest area of the test pattern for the lowest level of over-all illumination, and R_3, the corresponding range for the highest of the three illumination levels. The expansion in range of perceived brightness is obvious, and it occurs because of a dependence on luminance that is opposite in sign for the different areas of the test pattern: Whereas the brightest area gets brighter as luminance is increased, with the same increase in illumination, the darkest area in the configuration becomes progressively blacker.

Implications

The data expressed in brightness units confirm the conclusion already drawn from the data on luminance matches. We cannot accept the suggestion that there is a simple equivalence between fixed ratios of stimulus luminance and fixed ratios of apparent brightness, with brightness constancy resulting when the stimulus ratios are invariant. The data of Fig. 9 are in direct conflict with such a hypothesis.

The results have some interesting implications for the alternative "interpretation" or "correction factor" hypothesis, which requires that an observer be able to take into account the level of illumination. The data of Fig. 9 make it clear that even in the absence of "secondary cues," such as penumbras, highlight flecks, and so on, there is indeed a perceptual basis for differentiating between high and low illumination levels in terms of the difference in brightness gradients at the different levels (*10*). But to assume that the gradient discrimination could serve as a correction factor for illumination level and yield a result of perceived brightness constancy would be both circular and absurd, since the difference in brightness gradients at the different levels is itself based upon departures from brightness constancy in both the brightening and darkening directions.

It is difficult, furthermore, to see how the different brightness ranges could be accounted for in terms of Helson's (*11*) quantitative formulation of adaptation-level theory, which states, in essence, that the zero of organic functions shifts with changing conditions, thereby preserving invariant relations between the stimulus field and the organism. Presumably, in the experiments reported here, the adaptation luminance was approximately equal to the luminance of the focal area for which complete brightness constancy was most closely approximated for the three levels of over-all illumination. Relative to this adaptation luminance for constant perceived brightness, however, the photometric luminances of the remaining areas of the test pattern and of the background remain in constant ratio with respect both to the adaptation level and to each other. Unless one resorts either to ad hoc manipulation of the constants in Helson's quantitative adaptation-level formulation or to a systematic exploration of what he calls the residual terms of his general formula, we do not see how consideration of "adaptation level" alone can account for the fact that *both* the lighter and darker focal areas depart from the adaptation level in apparent brightness by different amounts at the different levels of illumination.

The opponent-colors formulation that we ourselves have been exploring in comparable experiments concerned with the *chromatic* aspects of perceived color (*9, 12*) assumes that the perceptual response in any focal area will be a function of a number of variables: (i) the focal stimulation per se; (ii) the momentary sensitivity of the responding mechanism; and (iii) the ongoing physiological activities in the focal area

that are not directly determined by the focal stimulation. These ongoing activities include spontaneous events, which would presumably be of significance at near-threshold stimulus levels, and usually also include induced activities that depend on immediately preceding stimulation of the focal area, or on induced activities dependent on simultaneous stimulation of the nonfocal, surround areas, or on both. The latter two factors are clearly involved in the ordinary brightness contrast and constancy situations, of which the experiments discussed here are an example. The general nature of induced effects has been shown to be one of antagonism and proportionality. Illumination of an area surrounding a focal area induces blackness in the focal area, and in proportion to the magnitude of the surround excitation. The relative effectiveness of a constant blackness increment (or brightness decrement) in a focal area is small where the direct response to the focal stimulus is large, and the induction increment becomes progressively more significant as the direct focal response decreases in magnitude. This concept of opponent spatial interaction at the physiological response level accounts for the perception of increasing blackness with increasing illumination of the surround—a phenomenon that cannot be accounted for in terms of adaptation or sensitivity changes alone. The physiological, opponent induction concept derives from both Hering (*13*) and Mach (*14*). The perceptual effects of such induced response activities have long been obvious in unusual phenomena such as Mach rings, as well as in the commonplace observation that dark objects definitely become "blacker" as the room illumination is increased from an initially "dim" level; and quantitative results of the sort reported here for a relatively complex stimulus pattern are actually predictable from the classical experiments with simple infield-surround field configurations of the sort first reported by Hess and Pretori (*3*) and from the shadowed illumination experiments of Helson (*15*). Direct evidence for the physiological basis of opponent induction processes is more recent, and is beautifully demonstrated in the work of Hartline and Ratliff (*16*) on the electrophysiological responses recorded from the eye of *Limulus*. The systematic, physiologically based, visual response relations involved in contrast and constancy situations need to be more fully explored and understood before we shall be able to deal with the nonspecific "judgmental" and "interpretive" processes that also influence our perceptions of real objects in the natural environment.

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Science in the News

The Last Days: Ike's Final Budget; Reports to Kennedy on Space and Disarmament; Wiesner's Appointment

The last Eisenhower budget, presented to Congress this week, is a liberal budget by the standards of 1953, or by Senator Goldwater's standards today, but a conservative one by the standards set during the campaign by both Kennedy and Nixon.

The budget calls for moderate increases in almost all categories of scientific research, and an aid to education program to assist both colleges and public schools in financing bond issues (as opposed to the more expensive grant programs talked about by Kennedy and Nixon during the campaign). The student loan program under the National Defense Education Act would not be increased, "pending further information as to the rate of applications."

In all, the budget recommends about $1 billion for support of education and $9.4 billion for support of research and development, mostly by the Defense Department. Both figures represent modest increases over last year's recommendations.

Even without a change in Administration, it is difficult to translate these recommendations into precise estimates of how much will be spent. Congress revises the budget, normally cutting more than it adds, and the Administration, although it is bound by the cuts, does not have to spend all the additional money voted. The result is that actual spending is usually less than the budget predicts.

This year the Eisenhower budget will serve primarily as a gauge to suggest how great a difference there is between Eisenhower's and Kennedy's views of what the federal government should do. Kennedy's revisions of the budget should begin to appear soon after his inauguration, and everyone assumes that the revisions will be uniformly upward, particularly in the areas of science and education.

Eisenhower, in closing his budget message, took special pride in pointing out that under his Administration the

country had succeeded in slightly reducing the share of national income being spent by the government. "We are convinced," he said, quoting from his first budget message in 1954, "that more progress and sounder progress will be made over the years as the largest possible share of our national income is left with individual citizens to make their own countless decisions as to what they will spend, what they will buy, and what they will save and invest." "This philosophy," he said, "is as appropriate today as it was in 1954. And it should continue to guide us in the future."

But it is clear that Kennedy has no intention of continuing this philosophy, nor that of Eisenhower's Secretary of the Treasury, Robert B. Anderson, whose comments on the budget re-emphasized his belief that "any decision to engage in overt fiscal action to stimulate the economy during a period of economic slack should await clear indications that [built-in stabilizers and expansive monetary policies] are not sufficient to promote resumption of growth."

Public Spending

The view of the Kennedy people is that while compelling cases can be made for a wide variety of projects that can only be financed through public spending, no one has made a compelling case for more consumer goods, the principal thing supported by private spending. And they reject Anderson's notion that the government should not decide to pump money into the economy in slack times until it becomes obvious that such a decision is unavoidable.

Both beliefs suggest that there will be very substantial increases in spending under Kennedy. He will be limited by his ability to get Congress and the public to accept tax increases, rather than by a belief that tax increases making a larger share of national income available for public spending are bad; and he is committed to press for more active federal intervention in the economy to try to assure a constantly growing national income, if only to assure a constantly growing tax base.

The Eisenhower budget shows only little evidence, for example, of being influenced either by the latest report of the President's Science Advisory Committee or by the report of the President's Commission on National Goals (*Science*, 2 December), both of which saw an urgent need for a sharp increase in government programs of support for basic research and higher education.

Eisenhower's view is that the nation cannot afford sharp increases in spending with the economy and tax rates as they are, and that tax increases or strong government action to avoid recessions are unthinkable. Kennedy's view is that, with national survival in danger unless we do better than we have been doing, Eisenhower's view is unthinkable.

The Kennedy people, and a good many others in Washington not associated with Kennedy, see Eisenhower's philosophy of government as coming close to a philosophy of government by wishful thinking. They had difficulty seeing the basis for Eisenhower's statement that "the economy is operating at a high level" at a time when the latest government report showed the number of unemployed to be the highest in 20 years, when we are facing a gold crisis, and when even the most conservative economists have come around to conceding that we are in a recession.

They were sadly amused at Eisenhower's prediction that the budget will be balanced this year, both because hardly anyone else believes it will be, whether the government intervenes to try and halt the recession or not, and because of the preoccupation with a balanced budget during a recession, when even Eisenhower's own staff economists believe that the government should incur a deficit rather than continue to let the economy stagnate. (The Associated Press reported that Eisenhower's prediction of a budget surplus was arrived at by simply taking the most optimistic assessment of several prepared by the Bureau of the Budget, one which by fine calculation managed to predict a surplus of $0.1 billion.)

His critics see the tone of Eisenhower's thinking reflected in the closing, and presumably climactic, paragraph of the opening section of his State of the Union message. "Success in designing and executing national purposes, domestically and abroad," he said, "can only come from a steadfast resolution that integrity in the operations of government and in our relations with each other be fully maintained. Only in this way could our spiritual goals be fully advanced." Just what this means, or was intended to mean, no one is quite sure. But it was assumed that Kennedy's inaugural address would offer something more specific as a basis for national policy making.

The President-Elect, meanwhile, continued to announce appointments and to receive the reports of his task forces. Jerome Wiesner, of MIT, for several years Kennedy's closest science adviser, was chosen as special assistant for science and technology. Wiesner had been assumed to be in line for the post, but what seemed to be a long delay in announcing the appointment had caused speculation that perhaps it would go to someone else.

A fairly reliable source says that Wiesner himself was reluctant to take the job, on the grounds that he would have preferred to devote his full time to problems relating to disarmament. The same source reports there has been lobbying against Wiesner's appointment from within the Defense Department—on the grounds that he was too much interested in disarmament.

Wiesner will have little trouble acquainting himself with his new responsibilities. In addition to having been for some time Kennedy's principal science adviser, he has been a member of Eisenhower's Science Advisory Committee for 3 years. Wiesner, as special assistant, will be *ex-officio* chairman of the Science Advisory Committee, as well as of the Federal Council on Science and Technology.

Kennedy announced the appointment simultaneously with the release of a task force report on space policies produced under Wiesner's chairmanship, which stressed above all what it saw as a need for firmer management of the program. The report suggested that there are too many competing programs, too much emphasis on the man-in-orbit project, a need to reinvigorate missile programs, lack of strong central direction to set priorities and keep the various programs in touch with one another, and not enough "vigorous, imaginative, and technically competent top management people in the National Aeronautics and Space Administration." Kennedy has assigned Lyndon Johnson, who was chairman of the Space Committee while he was in the Senate, general responsibility for seeing that all this is done.

Disarmament

Kennedy also received a report on disarmament, also put together under Wiesner's chairmanship. Although the full report was not made public, the New York *Times* said that it included

a recommendation to put off a resumption of the Geneva test-ban negotiations for about 6 months. This was part of a recommendation to avoid doing or saying anything much about disarmament until the new Administration could reach some firm decisions on a disarmament policy.

The delay on the general question was expected, for more than any other policy area the new Administration's policy on disarmament necessarily requires breaking new ground, and consequently time to develop a policy to which this country feels it can commit itself.

For the most part, this is easy enough to do: when nothing has been happening nothing is easier than to let nothing happen a little longer. But assuming its advisability, it will be awkward for Kennedy simply to postpone resumption of the test-ban talks. Opposition to continuing the present unpoliced ban has been growing throughout the year, and Kennedy, during the campaign, promised a prompt effort "with a reasonable but definite time limit" to see if the Russians are willing to come to realistic terms on the question. Dean Rusk, the incoming Secretary of State, said last week he expected a prompt effort to be made.

Kennedy would be opening himself to strong attack at home if he were to ask for a lengthy postponement. It is more likely that the talks will be resumed on schedule even if the Administration may feel that it will not have much to say until next summer, although this, too, would lay Kennedy open to criticism; he would hardly be in a position to set a "reasonable but definite time limit." We will know soon enough which course he decides to take, for scheduled resumption of the talks is only 3 weeks off.

There has traditionally been at least one scientist among the five Atomic Energy Commissioners, and there has therefore been an opening for a scientist since last summer, when John Williams, director of research at AEC before he was appointed a commissioner, resigned because of poor health.

But except for 2 weeks in 1958 when Willard F. Libby served as acting chairman, there has never been a scientist commission chairman. This week Kennedy chose Glenn T. Seaborg, chancellor of the University of California and a Nobel laureate in chemistry, as a commissioner, and designated him as chairman.

Apparently Kennedy wanted the chairmanship to go to a scientist, for the other man to whom the post was reportedly offered was also a scientist, James Fisk, president of Bell Telephone Laboratories and, like Seaborg, a member of the President's Science Advisory Committee.

All members of the Science Advisory Committee, incidentally, have submitted *pro forma* resignations as a courtesy to the new president, even though their terms do not expire with the old Administration. The offers of resignations are expected to be declined.

Of other major science posts, Herbert York has been asked to stay on as chief of research and engineering in the Defense Department; Keith Glennan has resigned as head of the National Aeronautics and Space Administration, but his successor has not been appointed; James A. Shannon apparently will continue to head the National Institutes of Health.

These three offices, together with the AEC chairman, are the chief ones responsible for overseeing more than 95 percent of the government's investment in research, and over 60 percent of the entire nation's research funds. A rough breakdown of figures: Defense, $7.4 billion; AEC and NASA, $1 billion each; and NIH, $500 million.

So far, virtually everyone is agreed, Kennedy has done very well. His appointments have been almost universally praised as the most intelligent, competent, and experienced group of officials Washington has seen in some years. Kennedy has achieved a principal preinaugural goal of broadening his base of support by bringing a number of widely respected Republicans into the top levels of his administration, giving weight to his claim that what he wants to do is not based on either doctrinaire liberalism or fuzzy do-goodism, but on a tough-minded appraisal of what the national interest demands.

Arthur Krock reported in the New York *Times* that there was more sense of excitement in Washington as Kennedy's inauguration drew near than he could remember since Franklin Roosevelt's first in 1932. Times have changed and problems are different. No one expects a very exact repetition of FDR's hundred days. But there is a feeling around that life will be interesting on the New Frontier.—H.M.

News Notes

Cockcroft Selected for $75,000 Atoms for Peace Award

Sir John Cockcroft, Nobel Prize winning British physicist, research administrator, and educator, has won the $75,000 Atoms for Peace Award, established as a memorial to Henry Ford and his son Edsel. Cockcroft will receive the gold medallion symbolizing the award at a ceremony to be held at the Massachusetts Institute of Technology on 6 April. In making the announcement, James R. Killian, Jr., chairman of the award trustees, said:

"Sir John's contributions to the peaceful uses of the energy within the atom range from the first demonstrations that this energy can be released by man's ingenuity and skill to the direction of the development of full-scale nuclear-powered generating stations supplying electricity to England. He has taken a leading part in the development of large-scale test reactors, in the organization and direction of one of the great research centers for the exploration of the peaceful uses of atomic energy at Harwell in England, in the distribution of radioactive isotopes for research and for medical therapy to many countries throughout the world, in the organization of a Middle Eastern Atomic Research Center in Teheran, in the organization of the Geneva Conferences on the Peaceful Uses of Atomic Energy under the sponsorship of the United Nations, in the training of scientists and engineers from many parts of the world at the school for the study of isotopes

Sir John Cockcroft. [Elliott Fry, Ltd.]

founded at Harwell, and in the discussions among scientists and diplomats about the ways in which the potential for benefiting mankind made available through atomic power can best be realized. . . ."

The award, set up in response to President Eisenhower's 1955 appeal at Geneva for international efforts to develop nuclear energy for peaceful purposes, is granted "solely on the basis of the merit of the contribution where ever found in the world and without regard for nationality or politics." Nominations for the 1961 award were received by the trustees from persons and learned societies in 24 countries.

Committee on Africa Formed; African Festival in West Germany

The creation of a National Advisory Committee on Africa was announced recently by the Institute of International Education. The committee, under the chairmanship of Reverend Theodore M. Hesburgh, president of Notre Dame, consists of persons who were chosen because of experience, knowledge, or responsibility in relation to Africa.

They will consider trends and needs as U.S. education becomes increasingly involved in Africa's problems. Among such concerns are the growing number of African students in this country, the recruitment of American teachers for African secondary schools, and the establishment of youth service programs in Africa. The committee will weigh means of improving the partnership between the U.S. Government and private agencies and institutions concerned with Africa. The Department of State has endorsed the formation of the new committee, and policy-making government representatives will be invited to its meetings.

German Festival

Between 21 October and 4 November, shortly before the IIE announced the formation of its committee on Africa, there was a nationwide demonstration in West Germany of interest in the freedom and well-being of the African states. The Africa Festival was planned to promote mutual understanding between the African states and the Federal Republic and to allow prominent figures to exchange information and opinion about various aspects of public life in Africa and Western Germany. The African visitors for the occasion included 130 parliamentarians, journalists, trade unionists, youth leaders, and teachers.

The extensive program of the festival included a meeting of African and West German journalists in Berlin, discussions between African and German trade unionists at Bergneustadt, near Bonn, and a conference between African and German parliamentarians. Poets from Africa and the Federal Republic met in Munich, exhibitions of African art were shown in Berlin, Bonn, Darmstadt, and Dortmund, and many other German cities scheduled lectures, films, and discussions about African countries. In Berlin, the German Institute for Cinematography sponsored an African Film Festival.

Although the event was sponsored by a private institution, the German Africa Society, the government showed a keen interest. President Lübke, the German head of state, gave a reception for the African guests. Among the speakers at the formal opening of the festival were Professor Erhard, the Minister of Economics, and Dr. Gerstenmaier, president of the Bundestag and also president of the German Africa Society.

Balloon-Borne Telescope Project Enters Testing Stage

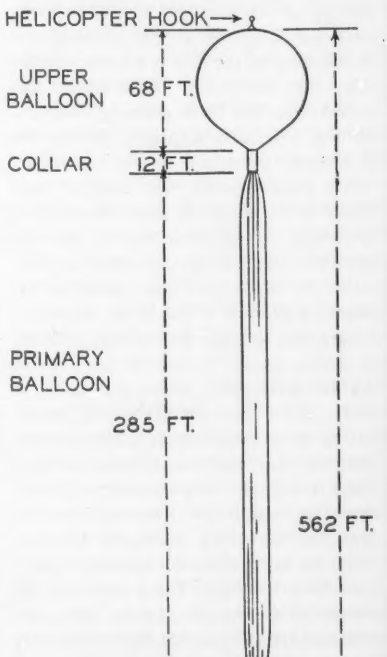
A tandem balloon system to lift the heaviest payload ever carried aloft to photograph planets and stellar nebulae is entering the preliminary testing stage, according to a joint announcement by the National Science Foundation, the Office of Naval Research, and Princeton University. Heart of the project, Stratoscope II, is a balloon-borne 36-inch telescope system weighing more than 2 tons, which will be raised to 80,000 feet (more than 15 miles), where it will be above nearly all of the atmospheric turbulence and dust that distorts or obscures ground-based observations. This permits picture-taking with a resolution three to five times higher than from the ground.

The project is under the direction of Martin Schwarzschild, internationally noted astronomer at Princeton University, who also directed the highly successful flights of a 12-inch solar telescope, Stratoscope I, in 1957 and 1959. The new program is sponsored by NSF and ONR, with additional support from the National Aeronautics and Space Administration.

Princeton has awarded a contract to a private research organization, Vitro Laboratories, Silver Spring, Md., to serve as program manager for Schwarzschild. Vitro's role is to supervise the development of the balloon system, evolve launching and recovery techniques, and plan and conduct the launches.

Objectives

The balloon will remain aloft throughout the night while observations are being made. The Princeton astronomers hope to be able to (i) analyze the divisions in Saturn's rings, possibly gaining more understanding of the factors that determine the orbits of the many particles that make up the rings; (ii) study the sudden atmospheric changes that take place on Jupiter and Venus (these studies may help to explain Jupiter's mysterious "red spot") and the possible relationships of these changes to solar



Balloon assembly for Stratoscope project.

magnetic storms; (iii) examine more closely the gaseous nebulae between stars, to gain clues as to the way in which our sun was formed; and (iv) obtain man's first look at the surface of cloud-shrouded Venus through holes that occur briefly in the cloud cover.

A proposed balloon system to lift the telescope payload, which, together with the associated electronic equipment, weighs about 4300 pounds, is under development by the G. T. Schjeldahl Co., Northfield, Minn. A new material developed by Schjeldahl, lighter and stronger than polyethylene, will be used for the balloon. It is basically Mylar plastic, reinforced with a Dacron mesh.

A method of utilizing a helicopter to capture the balloon and its payload as it descends, in order to achieve a soft landing, is also under development. An initial test of a helicopter-towed device for snagging the balloon has been completed by the Naval Air Development Test Unit, South Weymouth, Mass.

The first launch of the new system, with a dummy payload, and also testing of the helicopter retrieval method, is scheduled for this month. The target period for the first full-scale launch with the telescope is the fall of 1961.

AAAS Meeting Excerpts To Be Broadcast in New York

During the recent AAAS meetings in New York, radio station WBAI made recordings of talks and panel discussions from 16 of the symposia sessions and recordings of a number of interviews with distinguished participants. This material will be broadcast in a series of programs as follows:

23 January, 9:30–10:30 P.M., "Omnibus on Science." Chauncey D. Leake, president of the AAAS, talks with Jon Donald in the WBAI studios about the history of the organization and two of its principal concerns: communication with the public and the responsibilities of the scientist.

24 January, 9:00–9:30 P.M., "Flying Telescopes." Martin Schwarzschild of Princeton University talks about galactic structure, stellar "catastrophes," and the use of "orbiting astronomical observatories."

24 January, 10:30–11:00 P.M., "Science and the Polity." Pendleton Herring, president of the Social Science Research Council, considers this relationship in an address delivered during the symposium "Perspectives on Political Science and Science."

30 January, 9:30–10:00 P.M., "Extra-Terrestrial Communications." Physicist Phillip Morrison of Cornell talks with Paul Goodman and Jon Donald about "listening" for signals and discusses the communications patterns which could be developed by an extraterrestrial source to make its information intelligible to man.

2 February, 9:00–9:45 P.M., "The Challenge to Science of World Conditions Today." Sir Charles P. Snow delivers the meeting's principal address, in which he proposes the "moral uneutrality of science."

2 February, 10:15–11:00 P.M., "Science and Human Welfare." Margaret Mead, a member of the AAAS Committee on Science in the Promotion of Human Welfare, is joined by author Paul Goodman in a conference discussion, moderated by Jon Donald, of the role of ethics in science.

Carbon-14 Half-Life Redetermined

A more accurate value for the half-life of carbon-14—important in geological and archeological dating—has recently been obtained by the National Bureau of Standards. The new value is 5760 years, as compared with the previously accepted value of 5568 years.

In performing the redetermination, W. B. Mann and W. F. Marlow of the Bureau's radioactivity laboratory quantitatively diluted carbon dioxide of high specific activity for counting in length-compensated internal gas counters. Mass spectrometric analyses of parts of the undiluted gas sample were made by E. E. Hughes, R. M. Reese, and V. H. Dibeler, to determine the isotopic abundance of carbon-14. Experimental details of the redetermination will be published in the near future. Comparative measurements of the isotopic abundance were also carried out with H. W. Wilson of the United Kingdom Atomic Energy Authority.

The redetermined value is in fairly good agreement with the value 5900 ± 250 years obtained at the Bureau in 1953. The value 5568 years that has been in use was somewhat arbitrarily chosen. Because of the wide range in measured values of the half-life of carbon-14—from 4700 to 7200 years—a weighted average of three values determined by gas counting and by mass spectrometric analysis was tentatively accepted for radiocarbon dating of archeological samples. The present measurements have led to the conclusion that the uncertainties in the values obtained experimentally may have arisen almost entirely from adsorption effects.

The Bureau's new value of 5760 years is of particular interest in assessing the age, for example, of the Dead Sea Scrolls. On the basis of the previously accepted half-life, these scrolls were believed to be 1917 ± 200 years old—that is, to date from about 40 A.D. Their age, as estimated with the new value, is about 1983 years, and on this basis they date back to about 20 B.C. The difference in these two age values, however, is less than the experimental error originally given.

News Briefs

Air pollution. An advisory committee to the Surgeon General of the Public Health Service issued a report last month which recommends that support of air pollution research be increased from a current estimated level of $11 million annually to about $32 million a year by 1968. The report further recommends that the government assume 40 percent of this cost, industry 28 percent, and state and local governments 32 percent .

The committee was appointed by Surgeon General Leroy E. Burney, at the request of Secretary of Health, Education, and Welfare Arthur S. Flemming, after the National Conference on Air Pollution in November 1958. Copies of the report are available at the HEW Press Room, Washington 25, D.C.

* * *

Retiring biologists. Biology professors planning to retire are asked to register with the Retired Professors' Register at 1785 Massachusetts Ave., NW, Washington, D.C. The Association of American Colleges and the American Association of University Professors have established the office with the help of a Ford Foundation grant. The registry serves as a placement service for retired college and university faculty members and administrators who wish to be considered for appointments in institutions other than those from which they have retired. The demand for biologists is apparently greater than the registry's supply. The registry is directed by Dr. Louis D. Corcon.

* * *

TV mathematics. "Probability and Statistics," a nationally televised college-credit mathematics course, will be offered for the second semester o NBC's Continental Classroom, begin

ning 30 January. Presented by the Learning Resources Institute in cooperation with the Conference Board of the Mathematical Sciences, the course will be taught by Frederick Mosteller, chairman of the department of statistics at Harvard University, and Paul C. Clifford, professor of mathematics at Montclair (N.J.) State College.

More than 300 colleges and universities are expected to offer the course for credit. It will be carried by 170 stations, 5 days a week, from 6:30 to 7 A.M. Those enrolled for graduate credit will view additional lessons twice weekly. Financial support for the project is provided by the Ford Foundation and by several major industries.

* * *

Cardiovascular agents. The National Academy of Science–National Research Council has announced publication of the first volume of the three-volume *Index-Handbook of Cardiovascular Agents*, which contains information drawn from 13,427 scientific papers, monographs, and reviews. Each entry is condensed to one or more lines of essential content and indexed according to chemical and biomedical terms. More than 400 scientific journals, published from 1951 to 1955 in 20 different languages, were examined in preparing the volume. It has been labeled volume 2 of the series; volumes 1 and 3 (to appear within the next 2 years) will cover the periods 1931–50 and 1955–60, respectively.

* * *

Frontiers in chemistry. The 20th annual Frontiers in Chemistry lecture series at Western Reserve University will cover two major topics: part 1, "The Solid State"; part 2, "The Chemistry of Large Molecules." The lectures will be scheduled on consecutive Fridays from 10 February through 21 April, with the exception of 31 March. Part 1 will be opened by D. A. Vermilyea (General Electric Research Laboratory), who will talk on "The growth of solids." Part 2 will be opened by Robert Mesrobian (Continental Can Company), who will speak on "Preparation and properties of multi-component polymer systems."

* * *

Interdisciplinary conferences. A new program of international, interdisciplinary conferences has been initiated by the American Institute of Biological Sciences, under the direction of Frank Fremont-Smith, for many years medical director of the Josiah Macy, Jr. Foundation. Offices of the Interdisciplinary Conference Program are in the Time and Life Building, at Rockefeller Center, New York.

The conferences will consist of approximately eight series of five annual 3-day meetings. Each series will concentrate upon a significant biological problem, while each annual meeting—limited to 25 participants—will explore some one aspect of the problem in depth.

Grants, Fellowships, and Awards

Aeronautics. The Daniel and Florence Guggenheim Foundation (120 Broadway, New York) has announced its fellowship program for graduate study in rockets, jet propulsion, space flight, and flight structures. Eighteen fellowships are available for work at the Guggenheim Jet Propulsion Centers at Princeton University and California Institute of Technology and at the Columbia University Institute of Flight Structures.

The awards provide tuition and stipends ranging from $1500 to $2000 to science and engineering students who are residents of the United States or Canada, who have outstanding technological ability and qualities of leadership, and who intend to make a career in rocketry, jet propulsion, flight structures, or astronautics. Applications and credentials must be filed with the university of the applicant's choice *by 1 March*.

Ornithology. Awards for ornithological research are made in April of each year by the Frank M. Chapman Memorial Fund Committee of the American Museum of Natural History, Central Park West at 79th St., New York 24, N.Y. Applications should be received *by 1 March*.

Teacher research participation. The National Science Foundation has a summer program which enables teachers of science and mathematics to participate in research at colleges, universities, and research foundations by actually working, on an individual basis, in the laboratory or in the field with experienced scientific investigators. Requests for brochures, application forms, and other information should be sent to the director at the host school, since each school administers its own program in the light of its own requirements. Teachers are urged to apply as early as possible to the institution of their choice, and *no later than 1 March*. An announcement listing all institutions conducting research participation programs can be obtained from the foundation, Washington 25, D.C.

Travel for junior investigators. Funds to cover the cost of round-trip, air-coach travel are available to junior investigators engaged in or receiving training in the neurological, otolaryngological, and related sciences who plan to attend the following international meetings: Seventh International Congress of Neurology, Rome, 10–16 Sept.; Fifth International Congress of Electroencephalography and Clinical Neurophysiology, Rome, 7–13 Sept.; Fourth International Congress of Neuropathology, Munich, 4–7 Sept.; Seventh International Congress of Otorhinolaryngology, Paris, 23–29 July.

Letters of application should be sent *by 1 March* to the executive secretary of the selection committee, Dr. Adolph L. Sahs, Department of Neurology, State University of Iowa, Iowa City.

The letter should include a brief summary of the applicant's educational, occupational, and research background and should indicate his major field of interest. It should be signed by the applicant and countersigned by his administrative executive. The travel funds have been made available through grants to the selection committee from the National Institute of Neurological Diseases and Blindness of the Public Health Service and from the National Science Foundation.

Scientists in the News

Shannon McCune, geographer provost of the University of Massachusetts and a member of the U.S. National Commission for UNESCO, has been appointed director of the department of education in the UNESCO secretariat. He takes up his new duties in Paris this month. Greatly expanded UNESCO educational activities in tropical Africa, as well as programs in Latin America, the Middle East, the Far East, and other areas, will be under McCune's administration.

Irvine H. Page of the Cleveland Clinic, Cleveland, Ohio, has been elected a foreign member of the Brazilian Academy of Sciences.

Leo A. Goodman, professor of statistics and sociology at the University of Chicago, is on leave for the current academic year to serve as visiting professor at Columbia University.

The editorial board of *Modern Medicine*, international medical journal, has presented ten Distinguished Achievement Awards for work which has directly influenced medical progress in the United States. The award winners follow.

David P. Barr, president and medical director of the Health Insurance Plan of Greater New York, for his contributions in the fields of parathyroid disease and atherosclerosis and as a teacher of teachers. He recently retired as professor of medicine at Cornell University and as physician-in-chief at New York Hospital.

Lowell T. Coggeshall, vice president in charge of medical affairs at the University of Chicago, for his service as an administrator and medical statesman and for achievements in tropical medicine.

Julius H. Comroe, Jr., director of the Cardiovascular Research Institute of the University of California, for leadership in the investigation of pulmonary function and the clinical use of autonomic drugs.

Frank J. Dixon, Jr., professor and chairman of the department of pathology at the University of Pittsburgh, for contributions to the understanding of antibody production and diseases of connective tissue. Dixon this year will take over as director of experimental pathology at the Scripps Clinic and Research Foundation at La Jolla, Calif.

Rene J. Dubos, Rockefeller Institute for Medical Research, for fundamental work that helped usher in the era of antibiotics.

William F. Hamilton, professor emeritus of physiology at the Medical College of Georgia, for work in cardiovascular physiology and pathology that laid the basis for cardiac surgery.

Charles A. Hufnagel, professor of surgery at Georgetown University, for development of surgical techniques for treating heart and great-vessel disorders.

Severo Ochoa, professor and chairman of the department of biochemistry at New York University, for his demonstations of enzyme catalysis, ribonucleic acid biosynthesis, and muscle function.

Marion B. Sulzberger, director of the Skin and Cancer Unit of New York University–Bellevue Medical Center, for integration of basic science and clinical dermatology.

George W. Thorn, physician-in-chief of Peter Bent Brigham hospital and Hersey professor of the theory and practice of physic at Harvard, for contributions to the understanding of metabolic disease and stress patterns.

Carl S. Marvel will join the University of Arizona faculty on 1 February as professor of organic chemistry, after a long and distinguished career in teaching and research at the University of Illinois. Some 150 graduate students have earned Ph.D. degrees in organic chemistry under his direction.

Marvel, a past president of the American Chemical Society, is a specialist in the synthesis of organic compounds. He has done extensive research on the chemistry of sulfur in university, industrial, and government laboratories and has made significant contributions in work on synthetic rubber.

P. J. W. Debye, professor emeritus of chemistry, Cornell University, will be Cornell's George Fisher Baker lecturer in chemistry during the spring term. He will discuss molecular forces, between 14 February and 9 March.

Thomas A. Nevin, bacteriologist at the National Institute of Dental Research, Bethesda, Md., resigned last month to become assistant director for administration of the Germfree Life Research Center, Tampa, Fla.

Gertrude M. Cox of North Carolina State College has received the 1960 Gamma Sigma Delta Award for distinguished service to agriculture. She is recognized internationally for her outstanding contributions to statistics.

Dr. Cox has directed the college's Institute of Statistics since it was organized in 1944. In 1946 the institute became a part of the Consolidated University of North Carolina at Chapel Hill, and a department devoted to research and teaching in theoretical statistics was established on the Chapel Hill campus. On 1 July 1960, Dr. Cox became head of the Statistics Research Division of the newly formed Research Triangle Institute, a nonprofit research group supported by the three institutions of the area—Duke University, North Carolina State College, and the University of North Carolina.

Clifford F. Johnson has been named chief of the Office of Research Information at the National Institutes of Health, Bethesda, Md. For the past several months he has been chief of public information in the office he now heads. Prior to his transfer to NIH in April 1957, Johnson was assistant chief of technical information in the Office of the Army Surgeon General, where he had served for 16 years.

Recent Deaths

Edward Block, Baltimore, Md.; 58; senior vice president and general manager of the Chemicals Division, Olin Mathieson Chemical Corporation, New York; 4 Jan.

Daniel F. Brophy, Westport, Conn.; 61; psychiatrist and dean of students at City College, New York, for the last 14 years; 18 Dec.

Edith Bowen Chase, Leonia, N.J.; 61; assistant dean of faculty and associate professor of biological sciences at Hunter College; had taught at Wellesley and Hood colleges; 8 Jan.

Jefferson H. Clark, Philadelphia, Pa.; 70; chief of laboratories for Philadelphia General Hospital for 27 years before his retirement, 3 years ago; former associate professor of pathology at the University of Pennsylvania and director of laboratories for Temple University; 8 Jan.

Charles H. Heacock, Memphis, Tenn., 72; professor of radiology at the University of Tennessee Medical School; 30 Dec.

Lester S. Hill, Bronxville, N.Y.; 70; retired professor of mathematics at Hunter College and a noted cryptographer; before joining Hunter in 1927, taught at the University of Montana, Princeton University, the University of Maine, and Yale University; 9 Jan.

Leo Kaplan, Carbondale, Ill.; 42; associate professor of botany, Southern Illinois University; 2 Dec.

John A. Lapp, Macapawa, Mich.; 80; sociologist, specialist in vocational education, and labor arbitrator; former professor of sociology at Marquette University, where he wrote several high-school textbooks in civics and sociology; throughout the Roosevelt and Truman Administrations served as referee in labor disputes; 30 Dec.

Rev. **William F. Lynch**, Davenport, Iowa; chairman of the department of biology at St. Ambrose College; 5 Dec.

Roland McKee, San Francisco, Calif.; 80; retired horticulturist and agronomist; served the U.S. Department of Agriculture for more than 43 years; 19 Dec.

David Rapaport, Stockbridge, Mass.; 49; psychologist and a member of the Austin Riggs Foundation since 1948; previously was chairman of research at the Menninger Foundation in Topeka, Kan.; specialist in diagnostic psychological testing procedures, the psychology of general paresis, and the organization and pathology of memory and thinking; 14 Dec.

Book Reviews

Who Wants Disarmament? Richard J. Barnet. Beacon, Boston, Mass., 1960. xviii + 141 pp. $3.50; paper, $1.45.

The major dilemma of the current arms race lies in two fundamental truths that are stated by Under Secretary of State Chester Bowles in an excellent introduction to this book. The first is that arms races throughout history have *usually* ended in war. The second is that unpreparedness and unilateral, or unsafe, disarmament have *always* ended in national catastrophes.

There are two fundamentally different approaches for dealing with this dilemma. The first, now known as arms control, is to try to raise the odds that the arms race does not lead to total thermonuclear disaster. It accepts the continued existence of thermonuclear weapons and delivery systems but tries to alter national postures and intentions to make a nuclear explosion less likely. Although he hedges his conclusions, Barnet seems to reject this approach as failing to come to grips with the fundamental problem of the thermonuclear age, that is, with the existence of very large thermonuclear stockpiles.

This leads the author to seek a solution to the second problem: to devise a multilateral, safeguarded disarmament scheme that would lead to peace and not to national catastrophe. Unfortunately, the book fails to take a hard look at the political and military problems and assumptions of total and complete disarmament. It pleads, instead, for research of a technical nature. In the final analysis, the author argues that we should look hard and then take the risk because the other course leads to disaster. In making this plea, he is reversing Bowles' presentation by suggesting that the arms race must lead to war and that disarmament may not. Although this is frequently asserted, Barnet has not brought us any closer to a demonstration of how it can be done.

In the tradition of books on disarmament, the author felt it necessary to review the efforts made toward disarmament since World War II. In doing so, and in particular in his discussion of the Baruch plan, he displays a sophistication and an awareness of the reality of international politics which seem to be lacking in his later proposals. In addition, the book begins to fill the great void in our knowledge about Soviet attitudes toward arms control. In a way this is the most disappointing chapter in the book. Barnet, who is connected with the Russian Research Center at Harvard University, might have been expected to provide a penetrating analysis of Soviet motives. His analysis of Soviet doctrine leads him to the conclusion that serious disarmament negotiations with the Soviets are not possible. He then jumps to a discussion of hopeful signs and signs of progress and concludes that we should not let our awareness of the contradiction between disarmament and Marxist ideology stand in the way of possible negotiations.

We need to know much more about arms control than we now know before we either dismiss it, as Barnet seems to do, or completely accept it. What we know suggests that, without a radical alteration in the nature of man and international society, total disarmament will not mean an end to disputes, violence, or arms races. Until we have a much clearer idea of what it does mean and of what its consequences are, we should not accept disarmament as the goal. Even if we had all the evidence, we might still have to answer the author's question—if he means *total disarmament*—by replying "not us."

MORTON H. HALPERIN
Center for International Affairs, Harvard University

Graduate Education in the United States. Bernard Berelson. McGraw-Hill, New York, 1960. vi + 346 pp. $6.95.

As the destiny of our society grows ever more dependent upon specialized intellectual competence, the graduate schools of our universities are assuming an increasingly complex but vital role. Here at the apex of the higher-education pyramid, however, is found a near maximum of academic conservatism, and about these venerable heights have gathered thickening clouds of controversy. Pages of discursive debate about graduate education, its organization, its quality, its very validity, have multiplied in plentiful supply; opinions have been as numerous as solid factual knowledge has been scarce. As Bernard Berelson recognized at the outset of his endeavor: "The assumptions have been various; the values ambiguous or in conflict; and the facts alleged, contradictory, scanty, or altogether absent." There can be no doubt that we have been much in need of an extensive, objective study such as the one on which Berelson here reports.

Probably there has never been such a comprehensive survey of graduate education between the covers of a single book, certainly none based on as wide an array of accumulated fact and authoritative testimony. In an effort to bring understanding perspective to the first century of graduate work in the United States (1876 to 1976), the author draws with incisive care upon the accumulation of documents already available on library shelves. Concentrating his primary attention upon the years just past and those just ahead, he has drawn new and richly diversified insight from the field: from the practicing deans and faculties of the principal graduate schools; from young men and women who have recently earned graduate degrees; and from persons seeking to employ the products of graduate education.

As he summarizes his two years of effort under the sponsorship of the Carnegie Corporation of New York, Berelson speaks of having "read countless pages and collected numerous statistics, attended about 10 formal meetings, visited 20 or more institutions, secured about 45 disciplinary consultations, conducted 5 or so special studies, talked to over 150 people, and systematically collected facts and judgments

from about 80 graduate deans, 1800 graduate faculty members, 2300 recent recipients of the doctorate, 600 college presidents, and 70 industrial representatives." Through all of this he brought the trained eye of a social scientist to bear upon "the state of graduate education by institution and by discipline, in terms of what goes in, what comes out, and what happens in between."

The book is written with uncommon clarity of organization, with a somewhat clinical detachment, and happily, with an ever-present and welcome twinkle of unmistakably urbane good humor. Falling into three primary parts, the text deals first with the past in a discussion of "what has happened in graduate education in this country"; in this section the author seeks "only to discern the limitations that the past imposes on the present and the lessons that it ought to teach." The second segment the present and the near future: "The present and the near future . . . is the body of the report and it is organized along the lines of the major problems now active." Section three carries the "conclusions, commentary, and recommendations: what should happen."

This final portion of the book, which is clearly founded upon the data presented earlier, carries some 21 formal suggestions. These range from recommendations pertaining to graduate programs, such as the creation of "more compact, more specified" designs of doctoral work and new approaches to the foreign language requirement, to plans for the creation of "a center for advanced studies in the humanities" and the establishment of a new standard-setting "Graduate University" in Washington, D.C. Berelson assumes such other positions as the following: financial support of doctoral students should be regularized but students certainly should not be completely subsidized; that industry should provide unencumbered block-grant support to graduate schools; that recruiting of candidates for doctoral work should be "conducted more systematically and more energetically"; that training for teaching should be given new thought and effective planning within doctoral programs; that "over the visible future the national load of doctoral study should be carried mainly by the presently established institutions of top and middle-level prestige"; and that there should be a strengthened national organization of graduate schools. As he makes abundantly clear, there is no shortage of basic issues to which graduate faculties around the nation should be addressing themselves, with a willingness to seek new solutions in a new era of responsibility.

Some readers may sense overtones here and there of excessive reverence for the "top prestige universities," and others may occasionally want to argue that impressive institutional size may not necessarily breed high quality in graduate work, but nonetheless this is a fine and enormously valuable summing up of the problems and challenges confronting a vital segment of American higher education. There will be many differences of opinion over the interpretation of portions of the data that Berelson has assembled, and many a prolonged argument over some of his recommendations. In providing a better lighted stage on which the debates can be held, however, the author has performed an invaluable service.

Berelson observes that "what American academic life needs is a sense of pride, of *esprit de corps*, of profession in the best sense. That is what the American graduate school must take the lead in supplying, to itself and its constituency." Berelson has surely served this high cause well, for in this book he asks the right questions. It is required reading for anyone seriously interested in the future of graduate study.

JOHN C. WEAVER
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University of Nebraska

Errors and Deception in Science. Essays on biological aspects of life. Jean Rostand. Translated from the French by A. J. Pomerans. Basic Books, New York, 1960. 196 pp. Illus. $4.

The six essays presented here have little unity and are best discussed separately. The title-essay, presented first, is the best of the lot. It includes a play-by-play account of the development of Blondlot's fictitious n-rays early in this century; curiously, the author does not tell about the role played by the American physicist Robert W. Wood in revealing the fraud. Details and references may be found in Martin Gardner's *Fads and Fallacies in the Name of Science* (Dover, 1957), an immensely more valuable source of this sort of *memorabilia* than Rostand's essay.

As with the first, so also for the remaining essays: for each of them a better version is already in print. The subject matter of "Biology and the law," treated by our biologist in a cramped and legalistic spirit, is handled by the jurist Glanville Williams in a most humane and biological way in *The Sanctity of Life* (Knopf, 1957). "The singularities of man" is less interesting than N. J. Berrill's *Sex and the Nature of Things* (Dodd, 1953). It is better to read Roger J. Williams' *Free and Unequal* (University of Texas Press, 1953) than Rostand's "Biology and maladjustment." The chapter "Biological unity and diversity" is a poor substitute for P. B. Medawar's graceful essay, *The Uniqueness of the Individual* (Methuen, 1957; Basic Books, 1958). And the final chapter, "Biology and the cinema" reads as though it had been cribbed from the *Encyclopaedia Britannica.*

Has this book any excuse for being? Perhaps, in its original form. Perhaps there is nothing better in French. But that is no good excuse for translating it into English; in this language it is second best throughout, as I have indicated above. It has not even the excuse for being that it constitutes a new synthesis. To me its publication seems no more than an attempt by the publisher to capitalize on the well-merited praise earned by Rostand's previous book, *Can Man Be Modified?* [reviewed in *Science* **129**, 1606 (1959)].

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Electrons and Phonons. The theory of transport phenomena in solids. J. M. Ziman. Oxford University Press, New York, 1960. xiv + 554 pp. Illus. $13.45.

During the past 15 years remarkable advances have been made in understanding the behavior of semiconductors and metals. This text on the theory of transport phenomena offers a unified presentation of much of this progress. The author starts with a discussion of lattice vibrations and the one-electron theory of the electronic structure of crystals. Chapters on electron-electron

and electron-phonon interactions precede a discussion of the formal theory of conduction. Detailed discussions of electrical conductivity, thermal conductivity, and thermoelectric and galvanomagnetic effects are presented, with specific substances used for illustration. This is a book of theory rather than materials.

Many recent advances and new techniques, previously available only in the literature, are incorporated—for example, variational methods for the solution of the Boltzmann equation are applied throughout; the Onsager relations receive constant attention; and the Bohm-Pines collective electron theory is included, probably for the first time in a textbook. Where full details could not be given, a clear statement of the essence is given, along with references for the interested reader. One unfortunate omission is the theory of hopping-type conductivity of localized electrons appropriate to certain oxide semiconductors. This book is limited to study based on band theory.

Although the text is written "from the ground up," it is my belief that it will be of greatest benefit to the reader with a working knowledge of quantum theory and some background in solid-state physics. For the theoretical and experimental research worker in the field, it will be a most valuable possession. No reviewer could fail to mention the quotations given just beneath the chapter headings. These gems and the author's vivid and sometimes humorous similitudes add to the enjoyable experience of reading this book.

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Education and Manpower. Henry David, Ed. Columbia University Press, New York, 1960. xvi + 326 pp. $5.

The National Manpower Council, which was established at Columbia University in 1951 during the presidency of Dwight D. Eisenhower, is bringing its program of research to a close. The book that has just appeared, *Education and Manpower,* is a by-product of the work that has been in progress during the past nine years. Basically it consists of a series of staff papers prepared as the program progressed, but it also contains papers by Clarence Faust, "Our secondary schools and national manpower needs," and by Charles E. Odell, "Vocational guidance and the skills of the work force." In essence, the book is a summary of conclusions reached by the National Manpower Council in the course of its investigations.

Henry David, the Council's executive director, has written the introductory and concluding selections, and Eli Ginzberg, director of staff studies, has contributed a chapter on "Education and national efficiency." Substantial sections of the volume are devoted to secondary and higher education, with a somewhat shorter section on vocational guidance.

With the book's general thesis, the reader will find himself in complete accord. This thesis is stated in the opening sentence of Henry David's introduction: "Formal education is the foundation upon which the development of the nation's manpower resources is built." On the other hand, those who have been equally active in the fields of manpower and education may question the claim made on the jacket: "The selections which comprise *Education and Manpower* reflect a distinctive approach to some of the critical issues in education today." The value of this contribution to the subject is less in its distinctive approach than in its effective synthesis of the solid and constructive thinking that has been done on this vital subject.

It is unfortunate that the volume has not been brought more nearly up to date. Most of the selections appeared between the years 1954 and 1958, and more has happened since than can be covered in eight pages of supplementary notes. I do not wish, however, to detract from the soundness of the Council's thesis. Readers certainly will say "Amen!" to Henry David's warning that "the big danger . . . lies . . . in the possibility that the supply of highly trained men and women will not be adequate to the nation's future requirements. And this danger is enhanced if we fail . . . to increase the supply of young people of ability reaching the colleges; to strengthen the institutions of higher education; and, finally, to reduce the present degree of wastage of potential ability in the population. It certainly does not lie within the power of higher education alone to realize these objectives. Unless there is early identification of ability, a drastic improvement in the quality of secondary education, a more effective program of educational and vocational guidance . . . the stream of young people reaching college will remain too small."

HOWARD A. MEYERHOFF
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Washington, D.C.

The Physical Universe. Konrad Krauskopf and Arthur Beiser. McGraw-Hill, New York, 1960. 536 pp. Illus. $8.95.

The authors of this new elementary text covering the basic principles of physical science, but written for students who are not planning to specialize in science, undertook their task with a unique advantage: They set themselves the goal of condensing Krauskopf's *Fundamentals of Physical Science,* a text which has been employed on a large scale for well-nigh 20 years and which is still regarded by many as one of the best in the field. But simplification of an elementary text would, on the surface, seem to be either risky, impossible, or ruinous. Fortunately for the cause of education, the outcome proves successful beyond expectation, and the volume as it stands is a triumph of clarity, simplicity, and selectivity. It is the latter quality that often induces reviewers of textbooks to be petty and unfair because, do what you will from now until doomsday, the problem of choosing the items for inclusion in a text for a broad field must remain a personal one. All one can say in this instance is that the omissions made from the tested precursor are not fundamental. As for my own preference, I would have found it more useful had the authors left undisturbed the derivations of the equations for free fall and kinetic energy and omitted the page defining slugs and newtons, since the clarification of the distinction between mass and weight is well stated by them in prose anyway. It seems a little unfair to permit students to squeeze through a basic science course without sweating just a bit over the source, meaning, and practical value of an equation. But there is no reason why a conscientious teacher may not make an addition here and there, just as he often omits a section he finds expendable.

It would be redundant to go into details concerning the superior achievement of textbook authorship displayed

in this volume. Incidentally, the volume can boast of only an 18 percent reduction when compared with its parent text, but that figure tells only a small part of the story. In reading the smaller volume one feels that the authors were strongly aware of the need for brevity and strove hard to compensate with a gain in punch and lucidity. The illustrations are definitely far more meaningful than in the larger text, and significant bits of new material have been added here and there, out of respect to their timeliness. I am particularly pleased to see that many of the historical references in the older text, which showed the stamp of 19th century distortions, have been significantly mollified to bring them more in line with recent findings. The style is snappy and crisp. The placement of the questions and answers at the end of the book and the economical use of references will please both teachers and students. This book, more than any other in the field, may well be read with profit and pleasure by any literate man who wishes to know the alphabet and scope of modern physical science.

A few general comments may not be out of place here. It is hard to conceive that any college student (or high-school senior), even those who are neither particularly interested nor gifted in scientific-mathematical discipline, can fail to be deeply stirred intellectually by a course which employs a volume such as this one and which has a teacher that can give the text its real meaning. Such a student is bound to be better informed in science than is the average contemporary engineer in history, American literature, or modern painting. There is hardly a chapter in this book that does not pry the mind loose, challenge its latent powers to their limits, and enrich it with factual knowledge. Therefore, one cannot help being depressed by the post-Sputnik hysteria that erupted on several American campuses, one symptom of which was a blind rage against the general science courses and a demand for students, one and all, to return to the orthodox course of the 1920's. As a chemist on one campus put it: A year of real chemistry with holes in one's pants from nitric acid will teach a fellow more science and logic than 10 general science courses. And a friendly botanist beside him chimed in: And get his hands dirty.

How many people with holes in their pants and dirty hands, and feet too, learned little about science! No teacher using this volume would want to teach its contents without exhaustive demonstrations and some meaningful laboratory work. Moreover, on one campus it is a fact that, on senior college entry tests, nonscience students who had had the general science course (using the older Krauskopf text) did just as well as students who specialized in science, since, I presume, the tests dealt with general questions. Because the controversy is still dormant in many minds, it is a pleasure to see books such as the one under review, for their very existence speaks louder than words for the educational cause they serve.

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New Books

Mathematics, Physical Sciences, and Engineering

Activation Analysis Handbook. R. C. Koch. Academic Press, New York, 1960. 229 pp. $8.

Advances in Analytical Chemistry and Instrumentation. vol. 1. Charles N. Reilley, Ed. Interscience, New York, 1960. 462 pp. $12.

Adventures in Algebra. Norman A. Crowder and Grace C. Martin. Doubleday, Garden City, N.Y., 1960. 360 pp. $3.95.

Aeronautics and Astronautics. Proceedings of the Durand centennial conference. Nicholas John Hoff and Walter Guido Vincenti, Eds. Pergamon, New York, 1960. 470 pp. Illus. + plates. $12. Proceedings of the conference on aeronautics and astronautics held at Stanford University to celebrate the 100th anniversary of the birth of William Frederick Durand.

Analytical Quadrics. Barry Spain. Pergamon, New York, 1960. 144 pp. $5.50.

Annual Review in Automatic Programming. Richard Goodman, Ed. Pergamon, New York, 1960. 311 pp. Illus. $10. Papers read at the working conference on automatic programming of digital computers, held at Brighton 1–3 April 1959.

Arithmetic for the Modern Age. Aaron Bakst. Van Nostrand, Princeton, N.J., 1960. 348 pp. Illus. $4.95.

Background Material for the Development of Radiation Protection Standards. 13 May 1960. Staff Report No. 1. Federal Radiation Council, Washington, D.C., 1960 (order from Supt. of Documents, GPO, Washington 25). 39 pp. $0.30. The Council, established by executive order in 1959, advises the President with respect to radiation matters affecting health and offers guidance to federal agencies in the formulation of radiation standards. Its first staff report provides information on human exposure from radiation sources, the present state of our knowledge of the genetic and somatic effects of radiation, the problems of formulating radiation protection standards from available scientific data, and the basic and derived radiation protection guides. It also makes recommendations for further work by the Council and indicates areas where research is needed.

Bibliography and Index of Geology Exclusive of North America. vol. 23, 1958. Marie Siegrist *et al.* Geological Soc. of America, New York, 1960. 840 pp. $13.

Classical Electricity and Magnetism. E. S. Shire. Cambridge Univ. Press, New York, 1960. 412 pp. Illus. $7.50.

Continuous Geometry. John von Neumann. Princeton Univ. Press, Princeton, N.J., 1960. 310 pp. $7.50.

Determination of the Mechanical and Technological Properties of Metals. B. M. Gliner. E. Bishop, translation editor. Pergamon, New York, ed. 2, 1960 (translated from the Russian ed. 2). 169 pp. $8.50.

Digital Applications of Magnetic Devices. Albert J. Meyerhoff, Ed. Wiley, New York, 1960. 623 pp. Illus. $14.

Elements of Flight Propulsion. J. V. Foa. Wiley, New York, 1960. 456 pp. Illus. $12.50.

Elements of Maser Theory. Arthur A. Vuylsteke. Van Nostrand, Princeton, N.J., 1960. 375 pp. $9.50.

The Encyclopedia of Spectroscopy. George L. Clark, Ed. Reinhold, New York; Chapman and Hall, London, 1961. 803 pp. Illus. $25. More than 100 contributors have provided original articles for the volume, which are grouped under the following sections: "Absorption spectroscopy (spectrophotometry)—visible and ultraviolet"; "Band spectroscopy" (one article, 6 pages); "Beta-ray spectroscopy"; "Differential thermal analysis" (one article, 3 pages); "Electron paramagnetic resonance spectrometry"; "Emission spectroscopy—light" (47 articles covering 231 pages); "Flame photometry"; "Fluorophotometry and phosphorimetry"; "Gamma-ray spectrometry"; "Infrared emission spectroscopy"; "Infrared spectrophotometry" (35 articles covering 197 pages); "Mass spectrometry"; "Microwave spectroscopy"; Monochromators"; "Neutron spectrometry"; "Nuclear magnetic resonance spectra"; "Raman spectroscopy"; "Solar spectroscopy" (one article, 9 pages); "Vacuum spectroscopy" (one article, 10 pages); "X-ray and gamma-ray absorption photometry (absorptiometry)"; "X-ray characteristic absorption spectrometry" (one article, 2 pages); "X-ray diffraction or crystal spectra" (one article, 3 pages); and "X-ray emission spectrometry."

Fluid Mechanics through Worked Examples. D. R. L. Smith. With chapters on the stream function, circulation, vorticity, and potential function by J. Houghton. Cleaver-Hume, London, 1960. 344 pp. Illus. 28s.

A Guide to Mathematical Tables. A. V. Lebedev and R. M. Fedorova. English edition prepared by D. G. Fry. Pergamon, New York, 1960. 632 pp. $15.

A Guide to Mathematical Tables. Supplement 1. N. M. Surunova. English edition prepared by D. G. Fry. Pergamon, New York, 1960. 228 pp. $9.

Reports

Biphasic Action of Reserpine and Isocarboxazid on Behavior and Serotonin Metabolism

Abstract. In longitudal studies on psychiatric patients receiving therapeutic doses of reserpine and isocarboxazid, singly or in combination, we observed that the aggravation of psychotic symptoms sometimes occurring during treatment with reserpine was associated with a marked rise in urinary 5-hydroxyindoleacetic acid. Tranquilization was accompanied by a more moderate increase under the influence of reserpine, or by a reduction of 5-hydroxyindoleacetic acid excretion while on monoamineoxidase inhibitor medication. It is concluded that a moderate rise of free serotonin in the brain is associated with tranquilization, while a greater increase is accompanied by excitation.

It has been postulated that the psychic alterations induced by reserpine and monoamineoxidase inhibitors are mediated by biogenic amines such as catecholamines and serotonin (*1*). Most of the data on which this postulate is based were obtained in animal experiments by using relatively large doses of drugs. It is the purpose of this study to show whether or not correlations between behavioral changes and serotonin metabolism can be established in psychiatric patients receiving therapeutic doses of these psychotropic drugs.

Twelve patients, nine with schizophrenia (patients A to I inclusive) and three with mental deficiency (patients K to M inclusive), were placed on a constant protein diet previous to and during the entire period of investigation which averaged 47 days. They were given daily examinations including psychiatric interviews. The daily urinary excretion of 5-hydroxyindoleacetic acid (5-HIAA) was determined according to the method of Udenfriend *et al.* (*2*), and the 5-day averages were calculated on a basis of 100 g of protein per day. The investigation was divided into four periods: (i) placebo I; (ii) medication I in which seven patients received reserpine (Serpasil, Ciba, 4 mg/day), while isocarboxazid (Marplan, Hoffmann-LaRoche, 30 mg/day) was given to the other five patients; (iii) medication II in which all patients were placed on combined medication (Serpasil, 4 mg/day; Marplan, 30 mg/day); and (iv) placebo II. All medications were dissolved in water and taken orally.

We observed an aggravation of psychosis in six of the schizophrenic patients (Fig. 1). In three, (B, E, and G) the worsening occurred during the reserpine period, and two of these (B and G) suffered a second aggravation of the psychosis shortly after withdrawal of both drugs. In another schizophrenic (C) the first clinical symptoms of an activation of psychosis were observed towards the end of the combined medication, culminating in a severe state of mental disturbance after cessation of the isocarboxazid-reserpine treatment. In addition two patients (A, D) became mentally disturbed only in the second placebo period. Thus an activation of the psychosis was noted in 5 of 9 schizophrenics during the final placebo period. These changes in behavior were always accompanied by marked rises in urinary 5-HIAA in comparison with control levels. In addition evaluations of the daily changes showed increases in urinary 5-HIAA excretion previous to the activation of the psychosis. Clinical improvement was always associated with a fall in urinary 5-HIAA toward or to control levels.

Tranquilization took place in most patients during each of the three periods: with isocarboxazid, isocarboxazid-reserpine, and the second placebo period. We did not observe tranquilization during the initial reserpine medication, probably because its duration was too short to permit the calming action of that drug to develop. While under the treatment with the monoamineoxidase inhibitor, the most marked tranquilization was noted when 5-HIAA had fallen to its lowest values (left side of Fig. 2). This correlation was seen in 9 of 12 patients (C–H, K–M), while three others did did not become tranquilized. Two of the latter (A and I) showed only minor changes in behavior, although a reduction of urinary 5-HIAA was evident. Patient B, whose psychosis was activated during the reserpine period, improved somewhat under reseprine-isocarboxazid treatment and subsequently became much worse following the withdrawal of the combined medication. During disturbed periods his urinary 5-HIAA was always above control levels.

In those patients who retained tranquilization or became tranquilized during the second placebo period (right side of Fig. 2), we observed either reduced outputs of urinary 5-HIAA when monoamineoxidase inhibition was still retained as indicated by persistent high tryptamine levels, or merely moderate increases of that serotonin metabolite, when presumably a residual effect of reserpine continued for sometime after that of isocarboxazid had ceased (F, M and E, H, I, K, respectively).

Our observations were made on mental patients receiving much smaller doses of reserpine and isocarboxazid than the doses used in animal experiments. The correlations between behavioral changes and urinary excretion of 5-hydroxyindoleacetic acid indicate that, under our experimental condition, tranquilization was accompanied by a moderate increase of free serotonin in the body, while a greater rise was found previous to and during the aggravation of the psychosis in our schizophrenic patients. The clinical symptomatology of the acute exacerbations always followed the same pattern as in the recurrent activations the patients had previously experienced without any medication. An activation of the psychosis did not occur in 4 out of 9 schizophrenic patients and we never observed a psychosis-like state or marked excitement in the mentally defective group. In these patients, the urinary 5-HIAA excretion did not attain the elevated levels found in the other five schizophrenics previous to and during the periods of mental disturbance. From our results it seems that the endogenous indole metabolism of those schizophrenic patients who became mentally disturbed was more labile, for the relatively low doses of the drugs employed induced large alterations in serotonin turnover.

Figure 3 may be regarded as a schematic representation of our results

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Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

as well as a theoretical exposition of the drug effects in terms of free and bound serotonin. Placebo I represents the initial metabolic situation with more bound than free serotonin. Reserpine (medication Ia) releases serotonin from its bound form, thus producing a large rise in free serotonin which was found to be associated with an aggravation of the psychosis. A later effect (medication Ib) suggests a subsequent result of reserpine after the bulk of free serotonin has been washed out. Free serotonin is still increased, but the actual concentration is increased to a lesser extent depending on its rate of formation and destruction. This moderate rise is associated with tranquilization. It would seem that, when the serotonin concentration was low previous to reserpine medication, only a moderate rise of free serotonin could be evoked by reserpine, which again is also associated with tranquilization.

The period in which the patients received only isocarboxazid is omitted in this figure, as the behavioral and metabolic effects were essentially the same as those occurring during the combined isocarboxazid-reserpine medication. It would seem that the monoamineoxidase inhibitor antagonized the action of reserpine to release bound serotonin.

Giarman and Schanberg (*3*) came to a similar conclusion as they found that iproniazid alone, as well as in combination with reserpine, raises both the bound and free forms of serotonin in the brain, and the latter form to a greater extent. Probably the rise of free serotonin becomes most pronounced after saturation of the binding sites is achieved.

Our results suggest that a moderate increase of free serotonin during isocarboxazid-reserpine medication is correlated to tranquilization (medication IIa) while a greater increase (medication IIb) is associated with excitement.

The final placebo period (placebo II) is characterized by differential rates of decline in the activities of reserpine and isocarboxazid. There are individual differences, but as a rule reserpine effect is retained longer than the effect of the shorter-acting isocarboxazid. Another factor to be considered is the magnitude of the serotonin stores achieved just before drug therapy had been discontinued. As examples of a great number of possible results on serotonin and behavior after cessation of the combined medication, five different situations are outlined. If serotonin was moderately elevated during the reserpine-isocarboxazid period (medication IIa), and if isocarboxazid remains predominant at the beginning of the second placebo period, no additional serotonin can be re-

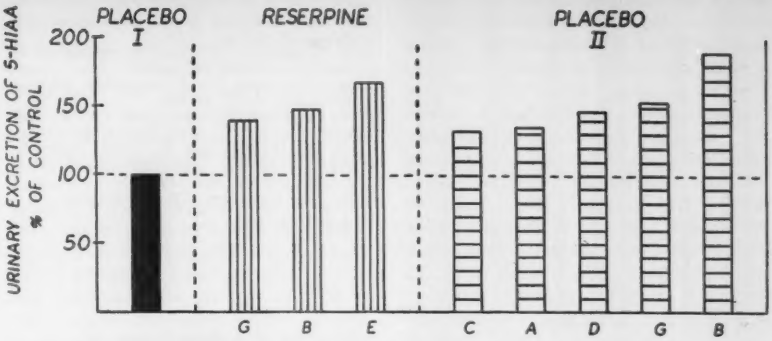

Fig. 1. Urinary excretion of 5-hydroxyindoleacetic acid during mentally disturbed periods. The bars represent the averages of 5-day periods in which the state of mental disturbance was most pronounced.

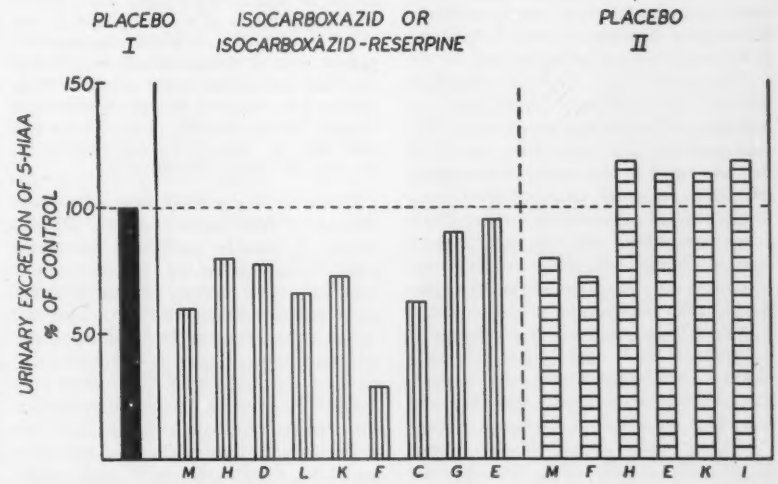
PLACEBO I
ISOCARBOXAZID OR ISOCARBOXAZID-RESERPINE
PLACEBO II
URINARY EXCRETION OF 5-HIAA % OF CONTROL
150
100
50
M H D L K F C G E M F H E K I

Fig. 2. Urinary excretion of 5-hydroxyindoleacetic acid during periods of tranquilization. The bars represent the averages of 5-day periods in which tranquilization was most marked.

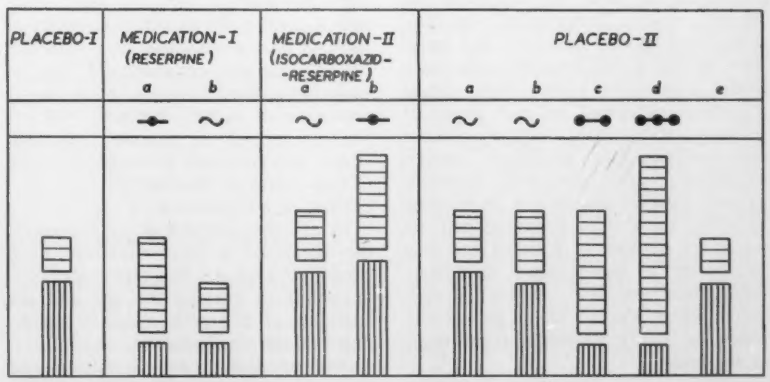

Fig. 3. Effects of reserpine and the combination reserpine-isocarboxazid (drug ratio, 1:7.5)on behavior and free and bound serotonin. The number of dots indicates different grades of excitement and mental disturbance; the wavy lines stand for tranquilization. The vertically lined bars represent the bound form of serotonin, and the horizontally lined bars represent the free form of serotonin.

leased and tranquilization is retained (placebo IIa). If, however, the isocarboxazid effect is weakened and merely a small amount of serotonin is released by the surviving action of reserpine, tranquilization continues as a behavioral correlate (placebo IIb). But when the reserpine effect is predominant over the isocarboxazid effect, and when most of the previously stored serotonin is released, free serotonin rises to the high levels associated with severe mental disturbance (placebo IIc). If the serotonin level was elevated markedly during the reserpine-isocarboxazid medication as indicated under medication IIb, and if reserpine continues to act after the monoamineoxidase inhibitor effect has ceased, even greater amounts of serotonin can be released and grave mental disturbance is observed (placebo IId). Finally, when both drugs have ceased to be effective the original biochemical and behavioral states are restored (placebo IIe).

The results show a close correlation between drug-induced alterations of behavior and serotonin metabolism, and they point to the conclusion that it is the free form of serotonin which parallels the behavioral changes. We know from clinical observations that both drugs, reserpine and monoamineoxidase inhibitors, may exert biphasic effects on the behavior of mental patients. They can evoke in the patient tranquilization as well as behavioral disturbance and aggravation of psychosis. These observations have their counterparts in the pharmacological effects of both drugs on serotonin metabolism; for both drugs, though acting by different mechanisms, can elevate free serotonin in the body, and it depends on the extent of this elevation whether tranquilization or disturbance will appear as a behavioral correlate. Whether or not the observed changes of indole metabolism also apply to the brain has not been determined in the present study. Experiments on animals have shown, however, that small elevations of free serotonin in the brain evoke a sedative effect, while larger elevations produced by high doses of 5-hydroxytryptophan, with or without monoamineoxidase inhibitors, induce excitement and disturbed behavior (*1*, *4*). Further studies are in progress to verify the results presented here on a greater number of patients and also to determine biochemical parameters other than serotonin, as the psychotropic drugs studied affect the metabolism of many chemical constituents of the body.

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21 September 1960

Variation of Enhancement of Photosynthesis with Conditions of Algal Growth

Abstract. The Emerson effect was observed as an enhancement of photosynthesis in long-wavelength red light when beams of shorter wavelength were added. Two light beams of wavelengths 650 and 694 mμ, respectively, when presented together, gave a photosynthetic rate higher than the sum of the rates obtained separately. The amount of enhancement of photosynthesis depends upon the growth conditions of algal cells, and specifically on their phosphate metabolism.

Emerson discovered that photosynthesis at a wavelength of about 700 mμ, which is usually inefficient in green plants, becomes more efficient when light beams of shorter wavelength are presented simultaneously (*1*). This he called enhancement. The enhancement of photosynthesis may be defined as the ratio of the rate of photosynthesis obtained by simultaneous illumination with beams of two wavelengths to the sum of the photosynthetic rates produced by illumination with each wavelength separately. The action spectrum of the effect caused by beams of shorter wavelength has been measured in several laboratories. Chlorophyll *b* is the chief pigment causing better utilization of the long-wavelength light in green algae (*2*). Furthermore, the same function is carried out by the phycobilins in red and blue-green algae (*3*, *4*). In different organisms enhancement may be variously achieved by the simultaneous activation of certain forms of chlorophyll *a* and of an accessory pigment which may be either chlorophyll *b*, the 673-mμ form of chlorophyll *a*, a phycobilin, or a carotenoid (*4*).

In a further analysis of enhancement, the effects of culture conditions have been examined. In this report the consequences of varying the age and the nutrition of *Chlorella vulgaris* and *C. pyrenoidosa* are discussed.

The unicellular algae *C. vulgaris* and *C. pyrenoidosa* were cultured in Knops solution of the following composition: $MgSO_4 \cdot 7H_2O$, 0.0103*M*; KNO_3, 0.0124*M*; KH_2PO_4, 0.0092*M*; K_2HPO_4, 0.0092*M*; and 1 ml of trace element mixture (*5*). Air containing 5 percent CO_2 was bubbled through the culture during growth. Continuous illumination was provided by two 15-watt fluorescent lamps 15 cm from the culture tubes (light intensity about 300 ft-ca). The temperature was held at 23.4°C.

Photosynthesis was measured by a polarographic method in which a stationary bright platinum electrode was used (*6*). The cells were illuminated by two light beams. The first beam, of wavelength 650 mμ, was presented by a monochromator with slits adjusted to give half band width of 5 mμ. A second light beam, of wavelength 694 mμ, from a small slide projector, presented a slightly oblique illumination to the cells. Its intensity was controlled by the lamp voltage, and its spectral character, by an interference filter having a half band width of 11 mμ, centered at 694 mμ. Red glass was used to cut off wavelengths shorter than 660 mμ.

The projector beam was adjusted to an intensity such that, after switching from the monochromator beam, an equal steady-state photosynthesis rate was obtained. The monochromatic beam was then added to the projector beam for the time necessary to obtain a new steady rate of photosynthesis. The procedure gives enhancement in terms of the total light presented—namely, as

$$\text{Enhancement} = \frac{\text{rates (650 + 694 mμ) presented together}}{\text{rate 650 mμ + rate 694 mμ presented separately}}$$

Several algal species (*Ochromonas sp.*, *Navicula minima*, *Amphora exigua*) cultured in this laboratory on complete media so far have never shown bichromatic enhancement of photosynthesis, perhaps because of unfavorable culture conditions or age. Table 1, lines 1 to 3, gives illustrative data.

Enhancement has always been found under favorable conditions in *Chlorella vulgaris* and *C. pyrenoidosa*. In these organisms the enhancement of photosynthesis varies during the growth cycle of algal cells. It is at a maximum in the logarithmic phase of growth, decreases during the stationary phase, and be-

Table 1. Variation of enhancement with conditions of culture.

Organism	Enhancement value
Ochromonas sp.	1.0
Navicula minima	1.0
Amphora exigua	1.0
A. exigua with pyrophosphate	1.5–1.6
C. vulgaris and *C. pyrenoidosa*, log phase	1.5–1.79
C. vulgaris and *C. pyrenoidosa*, stationary phase	1.3–1.5
C. vulgaris and *C. pyrenoidosa*, aged cells	1.0–1.1

Table 2. Factors influencing the enhancement of photosynthesis in *Chlorella*.

Line No.	Additions	Enhancement value
	Knops with phosphate excluded	
1	Complete Knops	1.5
2	Knops, 1/10	1.5
3	Knops, 1/20	1.0 –1.1
4	Phosphate, 10^{-2} *M*	1.25–1.5
5	None	1.0
6	$MnCl_2 \cdot 4H_2O$ (10^{-6} *M*)	1.0
7	H_3BO_3 (10^{-6} *M*)	1.0
8	$FeCl_3$ (10^{-6} *M*)	1.0
9	$ZnCl_2$ (10^{-6}*M*)	1.0
10	Mn, Zn, Fe, Cu, Co, and boric acid (10^{-6} *M*)	1.25–1.5
11	Pyrophosphate (10^{-5} *M*)	1.5 –1.8
	Complete Knops	
12	Pyrophosphate (10^{-5} *M*)	2. –2.5

comes negligible in aged cells, as seen in Table 1, lines 5 to 7.

The enhancement also varies with the composition of the medium. *Chlorella* cells transferred during their logarithmic growth phase to a medium deficient in phosphate, and illuminated further for 2 days, show no enhancement, as shown in Table 2, line 5.

If *Chlorella* cells, incubated in a medium with phosphate excluded, are transferred to a complete medium, enhancement is significant within 24 hours. Enhancement also persists if the cells are transferred to a complete medium which has been diluted tenfold. A 20-fold dilution of the complete medium prevents reactivation of the enhancement. The range of phosphate addition which reactivates enhancement is between 10^{-4} and 10^{-2}*M*. The addition of higher concentrations of phosphate does not increase the enhancement further.

To the phosphate-deficient medium various nutrients were added, as shown in Table 2, lines 4 to 10. Phosphate is not the only ion that reactivates enhancement of phosphate-deficient cells. A mixture of Mn, Zn, Fe, Cu, and Co, added as the chlorides, together with boric acid (10^{-6}*M*), reactivates enhancement within the same period of time as phosphate. The addition of these ions separately does not reactivate enhancement.

In contrast to the 24 hours needed for phosphate to reactivate enhancement, the addition of pyrophosphate to cells grown in phosphate-deficient medium reactivates enhancement to the normal value within 1 to 3 hours. The effect of pyrophosphate on cells in complete medium is dramatic: the enhancement is increased 70 percent above normal. Pyrophosphate is also effective in producing an enhancement in cells which do not show enhancement in complete media (Table 1, line 4).

These experiments emphasize that the Emerson effect is not a universal phenomenon but is dependent upon the algal species, the growth phase of the algae, and the culture conditions—specifically the phosphorus nutrition. How the presence of phosphate, and especially pyrophosphate, promotes the Emerson enhancement effect can only be surmised. That phosphates, and the pyrophosphate linkages, play a significant role in photosynthesis and sugar metabolism is well known (*7*). High-energy phosphate bonds, pyrophosphate, and polyphosphate groups result from illumination of chloroplasts in the presence of adenosine monophosphate and adenosine diphosphate. The energy stored in these structures is in some manner coordinated with photosynthetic reduction. That pyrophosphate is more effective in enhancement than phosphate suggests that the pyrophosphate is more readily converted into high-energy compounds than phosphate, and that both are utilized more effectively through the use of light beams of two wavelengths than through light of one wavelength. Whether the photophosphorylation reaction and the reaction forming the reducing power are driven by different pigment systems may be decided through further experimentation (*8*).

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19 October 1960

Concentration by Freeze-Thaw

Abstract. A simple procedure for concentrating aqueous solution by freezing is described. Solutions are frozen in test tubes, which are insulated on the sides and bottom, and allowed to thaw during centrifugation. Fractionation of solutes could also be achieved.

Several methods for concentrating dilute aqueous solutions are in common use. The simplest involves the boiling off of excess water. When heat-labile substances are to be preserved, evaporation at reduced temperature or sublimation of the water at temperatures below freezing are employed. These operations, especially the latter, are time-consuming and require special equipment. A simple procedure is described below which is based on the principle of separating the water from the solutes during freezing.

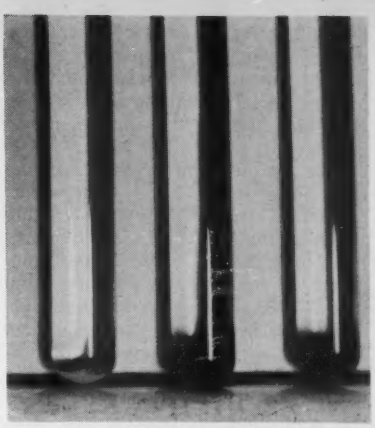

Fig. 1. Samples subjected to twice-repeated freeze-thaw in test tubes (length, 100 mm; diameter, 14 mm). The solutions used were 0.05-percent Bacto-tryptone (tube No. 1, left), Seitz filtrate of bacterial fermentation culture (tube No. 2, middle), and a mixture of the two (tube No. 3, right).

This procedure is based on maintaining and exaggerating the density differences that are established in the solution through freezing. The solution to be concentrated is poured into a test tube. The tube is insulated on the sides and bottom by wrapping with an appropriate material. The insulated tube, with the mouth open, is placed in a freezing chest in a vertical position, and the solution is allowed to freeze thoroughly. This arrangement causes the freezing to proceed downward from the top and causes the solutes to accumulate in the lower portion of the ice block. The frozen solution is allowed to thaw while it is being centrifuged. This maintains the established density stratification. Care must be exercised in handling the stratified solution to eliminate the possibility of local heating and generation of convection currents. The efficiency of separation depends on success in directing the freezing from the top of the test tube downward. The entire process may, if desired, be repeated several times to improve the separation.

The results of a twice-repeated "freeze-thaw" of each of three dilute solutions are shown in Fig. 1. Tube No. 1 contained a 0.05-percent solution of Bacto-tryptone (Difco), an enzymatic digest of casein. Tube No. 2 contained

Seitz filtrate of a bacterial fermentation culture. Tube No. 3 contained a mixture of the two solutions. Cotton was used as the insulation material, and the centrifuge force was approximately 3000 *g*.

The concentration of the dark pigments in tubes Nos. 2 and 3 is apparent: a separate layer of gray crystals is obscured at the bottom of these tubes. In tube No. 1, the layer of precipitate is apparent. I was able to separate, from tube No. 2, a colorless crystalline fraction and a heavily pigmented solution. Algaelytic activity observed in this filtrate was separated and concentrated in the pigmented solution fraction. By further controlling the freezing step—that is, freezing while spinning the test tube in a refrigerated centrifuge and narrowing the lower end of the tube—a further separation of different solutes from a heterogenous solution could be achieved. No tube breakage occurred in our relatively short (100-mm) test tubes; if longer test tubes are to be used, siliconizing of the glass surfaces might prevent the ice from sticking, thus enabling the ice to rise in the tubes.

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6 June 1960

Measurement of Geotropic Sensitivity of Seedlings

Abstract. By a new method of applying small centrifugal forces, produced by vibration of wires which hold corn seedlings on a horizontal clinostat, threshold values of the required gravitational force have been obtained. In darkness the centrifugal acceleration need be only about 0.04 cm/sec², while in weak light it must be 10 times as great.

The amount of gravitational force that is required to produce geotropic responses in seedling plants need not be as large as the force at the surface of the earth. An approximation of the mechanical force required to produce minimum geotropic curvatures in the seedling roots of *Lupinus albus* and of a dwarf variety of *Vicia faba* was reported by Czapek in 1895 (*1*). He used a series of centrifugal forces, scaled as fractions of gravitational force *g*, and recorded the time required to produce a perceptible bending of the root tip. His tests were conducted at 17°C, apparently in a room with ordinary illumination. He estimated the threshold force to be about 0.001 *g* because it gave a curvature of the root in 6 hours, while 0.0005 *g* produced no significant effect in 8 hours. I know of no more exact measurement of root sensitivity.

A new method has been developed for applying a similar series of very small centrifugal forces to certain seedlings which grow as they are rotated on a horizontal clinostat. Field corn, sweet corn, garden peas (*Pisum sativum*), and garden nasturtiums (*Tropaeolum majus*) have proved suitable for the method, but precise measurements of sensitivity to the centrifugal forces have been limited to a hybrid field corn, Master F-84.

The seeds are germinated in moist sand until the straight primary roots are from 2 to 5 cm long, in line with the coleoptiles which have just appeared. The young seedlings are lifted from the sand and strung like beads on a stiff steel wire, which is passed through the endosperm so that the root is perpendicular to the wire, preferably about 20 cm long. The base of the wire is held in a clamp that is bolted to the clinostat table so that the wire is rotated about its axis as it is held in a horizontal position, as in Fig. 1.

Care must be taken to avoid the induction of geotropic curvatures in the root tips by gravity after the seedlings are lifted. A moist chamber must be provided around the seedlings and the wire. Pads of wet cotton between closely spaced seeds at the base of the wire insure growth at points critical for the test. Only a few seedlings need be attached near the free end of the wire, where they help to maintain an even rate of vibration. Each test can be completed in 20 to 24 hours with optimum rates of growth.

The principle of measurement of threshold force required to produce a geotropic response in the root (and coleoptile) is that the vibration of the wire produces a measurable centrifugal force in the direction of the tip of the wire. The force decreases in strength from maximum at the tip to zero at the base of the wire. As every point along the wire oscillates in its arc of vibration, the centrifugal acceleration *a* (in centimeters per second per second) is determined by the equation $a = \omega^2 r$, where ω is the mean angular change in radians per second and r is the distance from the base in centimeters.

Table 1. Threshold values of centrifugal acceleration for geotropic response in corn seedlings at 23 ± 1°C.

Illumination	Acceleration (cm/sec²)	
	Growth curvature induced in root	No induced root curvature
Darkness	0.044 ± 0.024	0.019 ± 0.012
Laboratory lights by day	.507 ± .170	.270 ± .148

When the rate and amplitude of vibration are considerable, as with long wires turned 1 rev/min by an electric motor clinostat, all seedling roots grow in the direction of the centrifugal force while the coleoptiles of corn grow in the opposite direction, as shown in Fig. 1. Wires only a few centimeters long, or wires held firmly at both ends, vibrate too little to change the direction of root and shoot growth, though small, random curvatures may appear. But if the centrifugal acceleration along a wire with a freely vibrating tip is in the range of less than 1 cm/sec², the force close to the base of the wire proves to be subthreshold. A threshold value appears at a distance of 1 or 2 cm from the base, as shown by growth curvature of root tips away from the base, with the coleoptiles bending toward the clinostat motor, in Fig. 1.

To obtain this range of centrifugal force and to measure the amplitude and rate of vibration with a suspended binocular microscope and a stroboscopic tachometer, it was found advisable to use a clinostat with a spring-driven clock motor and a rate of rotation of one or two turns per hour. The necessary vibration is induced by something set nearby on the same table or bench.

There is such a variability in the geotropic responses of the seedlings, in their exact places along the wire, and in computed values of the centrifugal

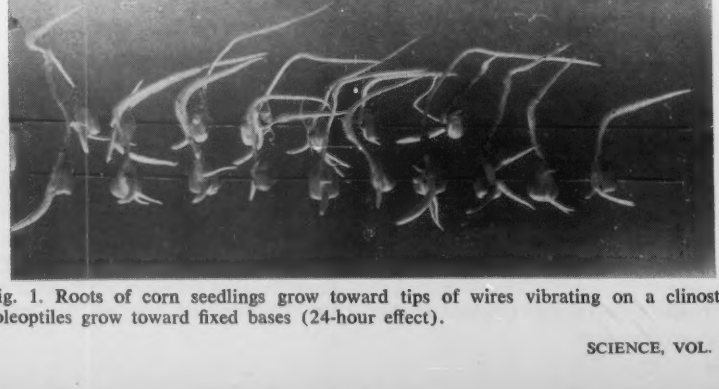

Fig. 1. Roots of corn seedlings grow toward tips of wires vibrating on a clinostat; coleoptiles grow toward fixed bases (24-hour effect).

forces near the base that no single measurement of threshold or subthreshold force is significant. Table 1 shows the means of six measurements with illumination and of 24 tests in darkness. From these evaluated means of forces for geotropic responses and no responses, one can only say that the threshold value lies somewhere between them, perhaps nearer to the mean for a distinct response. The tenfold difference between tests in darkness and in a lighted room agrees with previous observations (*2*) of greater sensitivity in darkness. Comparison with Czapek's estimate that an acceleration of 0.980 cm/sec^2 is threshold suggests that his failure to wait more than 8 hours for the effect of the force of 0.490 cm/sec^2 (compare our mean of 0.507) made his estimate double the true value for geotropic response in the light.

These decisive effects of very low centrifugal forces and the possibility of their production by slight vibrations must be considered if seedling plants are ever grown in a gravity-free state, as in manned space ships. The very low requirement of 0.044 cm/sec^2 for a mechanical force in darkness may also have a bearing on acceptable theories of graviperception (*3*).

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19 September 1960

Production of Polydipsia in Normal Rats by an Intermittent Food Schedule

Abstract. Marked polydipsia was produced in all animals trained to press a bar for food pellets on a 1-minute variable-interval schedule. It is suggested that since this feeding arrangement produces a sustained, high fluid intake in the normal, unrestrained animal, it might serve as a useful tool in the study of renal function.

Long-lasting, high rates of fluid ingestion can be roughly characterized as either metabolic or regulatory polydipsia. In the first case, high intake is a direct result of abnormal fluid losses (for example, as in diabetes insipidus), while regulatory or primary polydipsia usually is assumed to originate from a central nervous defect which stimulates neural thirst centers. Regulatory polydipsia can also be produced by chronic shifts in the volume and composition of water compartments of the body (for example, by sodium depletion).

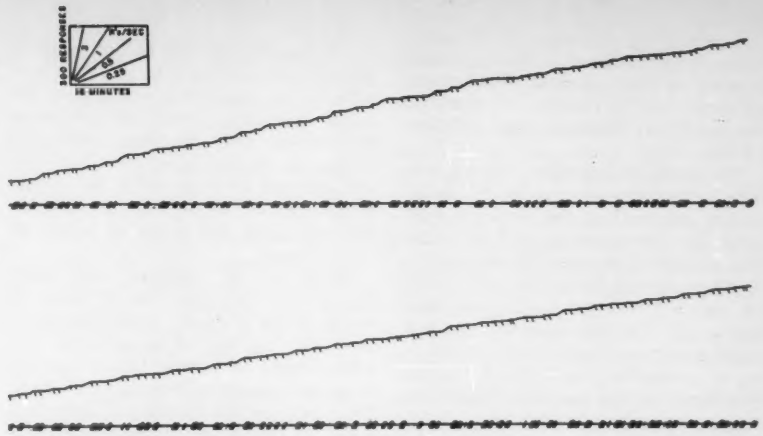

Fig. 1. Record of one complete VI-1′ session of bar-pressing for food pellets, showing a burst of drinking on the lower trace after delivery of the pellet (rat No. 6-3).

This report (*1*) concerns the production, in rats, of a type of regulatory polydipsia which, in human beings, would be classed as psychogenic.

Fourteen female, experimentally naive, albino rats (*2*) with a mean starting weight of 264 g were maintained at 70 to 80 percent of their starting weights on a 1-minute variable-interval (VI-1′) schedule of food reinforcement. Under this schedule, a bar-pressing response produces a 45-mg food pellet (*3*) at varying time intervals, the average of which is 1 minute (range, 3 seconds to 2 minutes). The variable interval (VI) schedule is designed so that no feature of the animal's behavior or the external stimulating conditions can inform the animal precisely when a bar-press will be reinforced by a food pellet. All presses occurring between the times when a pellet is readied for delivery by switching circuitry are ineffective but are recorded.

The animals were given daily experimental sessions lasting 3.17 hours. Water was available 24 hours per day. During the session a drinkometer recorded every lick from a glass drinking spout attached to a calibrated reservoir. In the animal's home cage water was available from a Richter tube.

Figure 1 is the record of one complete session for rat No. 6-3. Bar-pressing moves the pen up (the moves are cumulative), and the delivery of each food pellet is indicated by a short vertical line. The lower trace records every 12th lick on the water spout. A characteristic behavior pattern is evident. Shortly after a pellet is earned a burst of licking ensues, followed by a return to bar-pressing until the next pellet is delivered. Post-pellet drinking is usually so prolonged that the pellets which are potentially available at the shorter intervals (for example, 3 seconds, 10 seconds) are not earned as rapidly as they might be. In fact, although the animals are deprived only of food, a high proportion of their session time is spent in drinking.

Table 1 gives the mean water intake for all animals (i) in their home cages prior to the start of the experiment, with food freely available; (ii) during the daily session; and (iii) in their home cages between sessions. The average value for intake during the sessions is 3.43 times higher than the mean pre-experimental, 24-hour value. This difference is all the more impressive if we note that the usual effect of food deprivation in the rat is a sharp decrease in water intake (*4*).

The polydipsic effect develops rapidly. It is usually quite evident in the first VI-1′ session and often fully developed by the second session. It has

Table 1. Mean water intake of rats not deprived of water, during the pre-experimental (free food) period; during the VI-1′ session of bar-pressing for food; and in the cage between sessions (no food).

Rat No.	Mean water intake (ml)		
	Pre-exptl. (24 hr)	Exptl. session (3.17 hr)	In cage (20.83 hr)
1-1	36.50	77.33	0.83
1-2	41.50	106.00	1.00
6-1	22.00	67.66	0.50
6-2	29.00	121.00	1.66
6-3	16.60	98.00	0.83
6-4	23.80	79.33	0.33
6-5	18.20	146.33	0.50
6-6	29.50	99.33	0.33
6-7	28.00	81.33	0.83
PO-1	*	71.00	2.50
PO-2	*	76.66	0.16
PO-3	*	89.50	0.66
PO-4	*	81.00	2.50
PO-6	24.50	100.66	0.66
Av.	26.96	92.51	0.95

* Not measured.

never failed to develop in an animal exposed to this schedule. Further experiments are in progress to elucidate the conditions necessary and sufficient for this effect.

The methods typically used to produce a sustained diuresis in the intact animal are loading the stomach with water or administering sodium chloride, mannitol, or other diuretic agents. Another method forces intake by making shock avoidance contingent upon licking (*5*). The arrangement described in this report results in voluntary drinking at a sustained high rate in the unrestrained, normal animal, without the various traumatic concomitants of the above methods.

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References and Notes

1. This study was supported in part by grants-in-aid from the National Institutes of Arthritis and Metabolic Diseases (grant No. A-2911), the Nutrition Foundation, New York, and the Fund for Research and Teaching, Department of Nutrition, Harvard University School of Public Health.
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10 October 1960

Selective Localization of Tetracycline in Mitochondria of Living Cells

Abstract. The property of tetracycline to induce fluorescence has been used to determine its localization in living cells. It was found that this antibiotic, as well as the related antibiotics oxytetracycline and chlorotetracycline, specifically combines with the mitochondria of living cells, either in tissue culture or in fresh preparations from various organs.

In the search for a fluorophor which would selectively localize and remain localized on mitochondria in living cells, a number of substances were tried with varying results. Benzpyrene and related carcinogens, as used by Graffi (*1*), localized on mitochondria and on fat droplets. Glycerol was employed as a vehicle. Using acridine orange, Wolf (*2*) found that the distribution and size of metachromatic granules in viable cells suggest that these granules may be mitochondria. With this florophor we found a variable fluorescence, which made observations difficult to interpret.

Our attention was drawn to the work of Milch *et al.* (*3*) and Rall *et al.* (*4*), who studied the gross distribution of the tetracycline group of antibotics in normal and neoplastic tissues. The possible use of antibiotics would have the added advantage over use of many fluorescent dyes in that antibiotics would not markedly interfere with the development of living cells, and would simultaneously supply further information regarding the mode of action of tetracyclines.

Milch *et al.* reported that bone fluorescence persisted for at least 10 weeks when a single, small parenteral dose (0.3 mg/kg) of tetracycline was administered to freshly frozen sections of several species of laboratory animals. This induced fluorescence disappeared from all tissues except bone within 6 hours after injection.

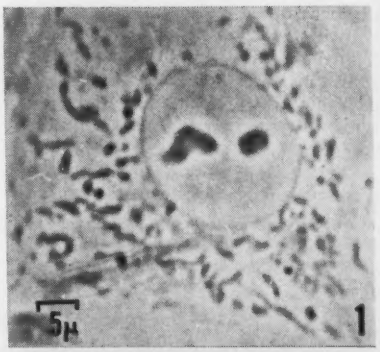
In the present study, observations on living cells are reported by means of phase-contrast and fluorescence microscopy.

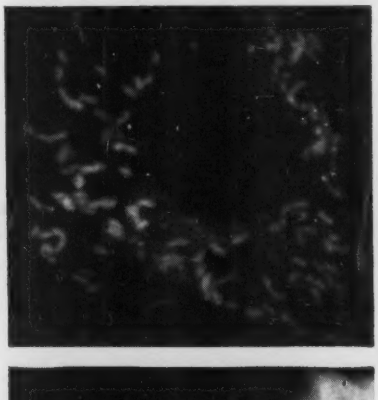
Monkey kidney tissue-culture cells, grown in medium 199 with 2 percent calf serum and maintained in Eagle's basal medium on submersed coverslips, were exposed to 10 or 20 μg of tetracycline per milliliter of medium. (The amount of tetracycline currently used in the antibiotic mixture added to tissue culture media to suppress bacterial growth is about 10 μg/ml.)

Photomicrographs were made of the same cell, first by phase-contrast (Fig. 1), then by fluorescence microscopy (Fig. 2). The mitochondria showed intense fluorescence. Nuclei, vacuoles, interparticulate cytoplasm, and cell boundaries appeared dark. Some decrease in the intensity of the yellow fluorescence occurred within a few seconds after exposure to ultraviolet radiation. In similar preparations made of the same material, and in the continued presence of the antibiotic, the cells were alive after 4 days and the fluorescence was still localized in or on the mitochondria. At concentrations of 100 μg or more cell damage occurred (*5*). When the tetracycline-treated material was resuspended in tetracycline-free medium, the fluorescence decreased gradually over several hours until the mitochondria were only faintly fluorescent.

No fluorescence was observed in chromosomes in dividing cells which had been previously treated with the antibiotic. Strain L cells showing a centrosome area did not show fluorescence of the centrosome. Similar results were obtained with tissue cultures which were exposed to oxytetracycline or chlorotetracycline (10 to 20 μg/ml of medium).

To test fresh isolates, adult mice were injected intraperitoneally with 1.0 ml of saline containing 2000 μg of tetracycline per milliliter, or approximately 100 μg/g of mouse; after 2 hours the animal was killed, and brain, liver, and spleen fragments were collected in 0.88*M* sucrose. Fresh microscopic preparations of these organs were made. The tetracycline was again localized on the mitochondria. Liver mitochondria





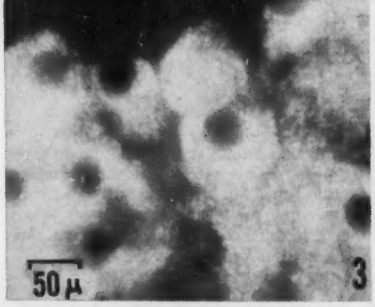


Fig. 1 (top). Living primary monkey kidney cells after a 3-hour exposure to 20 μg of tetracycline per milliliter (Chas. Pfizer). Phase contrast. Fig. 2 (middle). Same field as Fig. 1, showing mitochondrial fluorescence. Zeiss W microscope with mercury HBO-200 light source, used with two BG-12 exciter filters and barrier filter OG-5. Fig. 3 (bottom). Mouse liver tissue fragment mounted in 30 percent sucrose. Nuclei appear black in contrast to strong fluorescence by mitochondria. The animal was injected intraperitoneally with 2000 μg of tetracycline prior to death and observation.

showed strong fluorescence (Fig. 3), whereas the fluorescence of spleen mitochondria was moderate, and that of brain mitochondria weak. When additional tetracycline was added to the brain fragments, the fluorescent staining of the mitochondria was increased.

A similar selective localization was found in subcellular fractions when tetracycline at a final concentration of $5 \times 10^{-5} M$ (or approximately 20 μg/ml of the final solution) was added to a 25 percent mouse brain or liver homogenate, made in 0.25 *M* sucrose. The nuclear, mitochondrial, microsomal, and supernatant fractions were prepared by differential centrifugation. The particulate pellets were resuspended in sucrose with tetracycline, to make the equivalent of a 12.5 percent homogenate. Again, when exposed to ultraviolet radiation, the nuclei showed neither autofluorescence nor the specific fluorescence of tetracycline. This provides a useful way to determine contamination of nuclear preparations with mitochondrial fragments. In the mitochondrial fraction of the brain, the yeastlike "myelin bodies," which always contaminate this fraction, were dark. When crescents occurred in the mitochondria, the crescents showed stronger fluorescence than the remainder of the mitochondrion, which was barely visible. When the mitochondria disintegrated with sodium desoxycholate, the fluorescence became diffuse. Microscopically, the "microsomal" pellet showed a yellow diffuse fluorescence, whereas the fluorescence of the supernatant fluid was very faint, except for contaminating particles. The observation that the "microsomal" fraction showed diffuse fluorescence, whereas the interparticulate cytoplasm of the intact living cell appeared optically empty, seems to support our interpretation, given previously, that the "microsomes" are artifacts (*6*, p. 373) and do not occur as such in living, intact cells. To evaluate further this interpretation, the quantitative aspects of the intensity of fluorescence in various areas of the cell, as compared with that in isolated fractions, are being investigated with varying concentrations of the antibiotics.

An aliquot of the isolated mitochondria, prepared as described, was studied metabolically. (The presence of the usual cofactors and substrates (*7*) did not change the fluorescence of the preparation.) As reported by others (*8*), we also found that, under the conditions of our experiments, oxygen uptake was not changed, but oxidative phosphorylation was decreased (3.35 μmole of magnesium sulfate per milliliter was added to the Warburg vessels), with glucose as substrate for brain mitochondria, and fructose diphosphate for liver mitochondria.

A susceptible microorganism, *Salmonella typhosa* strain Ty 2, growing in nutrient broth, was treated with 50 μg of tetracycline per milliliter. Observations after 10 minutes showed a strong yellow fluorescence in distinct areas within the bacteria. The wall was faintly discernible, and the remainder of the intercellular area was dark. The particulates varied in location, size, and intensity of fluorescence, and appeared similar to those identified as mitochondria with Janus green B by Davis *et al.* (*9*).

Sequential observations of the distribution of the fluorescence in living cells are being made, in order to study the exchange between tetracycline-tagged mitochondria and nuclei during cell division, and changes in mitochondria after virus infection, or after the introduction of deficient media to the cell environment. Also, further information might be obtained about the locus of action of tetracyclines in cases where complications occur resulting from prolonged therapy—for example, liver degeneration (*10*)—or about the primary site of action of these compounds in susceptible microorganisms.

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28 September 1960

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Letters

Cost of Scholarly Books

Steven Ross's letter in *Science* [**132**, 835 (23 Sept. 1960)] rightly points out the high cost of scientific books. Yet many who cannot afford to buy would borrow, if they knew where. College students with access to good libraries are largely but not entirely free of this problem, but others find it pernicious.

The obvious answer is the public libraries, but even the best of these will have a skimpy representation in many fields. Probably this is inevitable in a local system, but why can't a large, national collection be built and maintained? This would not be an archive but a supplement to local libraries unable to meet specific requests. As Ross says, "to read is to learn"; such a project would certainly help spread scientific knowledge.

WOLFGANG WIEMER

B. S. Coler Hospital, Welfare Island, New York, New York

Your recently published plea by S. E. Ross regarding the need for cheaper books prompts me to voice a related pet peave. As a practicing clinician my mail is clogged with innumerable pieces of junk mail from drug concerns. Most of this is no doubt conceived, printed, and distributed at great cost. Yet a brief, admittedly statistically invalid, survey of my colleagues reveals that almost none of this material is ever opened, much less read. If it is opened it is only to identify it for what it is—an ad proposing that some company's new muscle relaxant, tranquilizer, or antibiotic is superior to its competitors' chemically identical product.

The distressing part of this is the fate of all that costly writing and printing—to wind up unseen in a trash can. Yet other printed matter, directed at the same scholar, is out of reach because of the cost of printing technical books. How much more practical, then, to direct the trash-can advertising money into subsidizing scholarly books. Perhaps only the dust cover could be bought for advertising at the start. Less costly printing and paper would help too.

There is, no doubt, a hard conservative core in the publishing industry which holds a book to be sacred and not to be contaminated by advertising. Somehow there is no objection to advertising in periodicals, and indeed *Science* itself would quite probably not be published if it were not for advertising. Small, highly specialized periodicals could certainly not be produced without advertising. Why, then, the difference between the periodical and the textbook?

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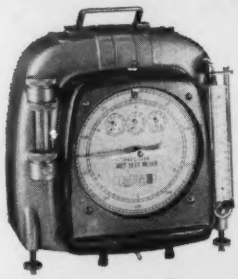

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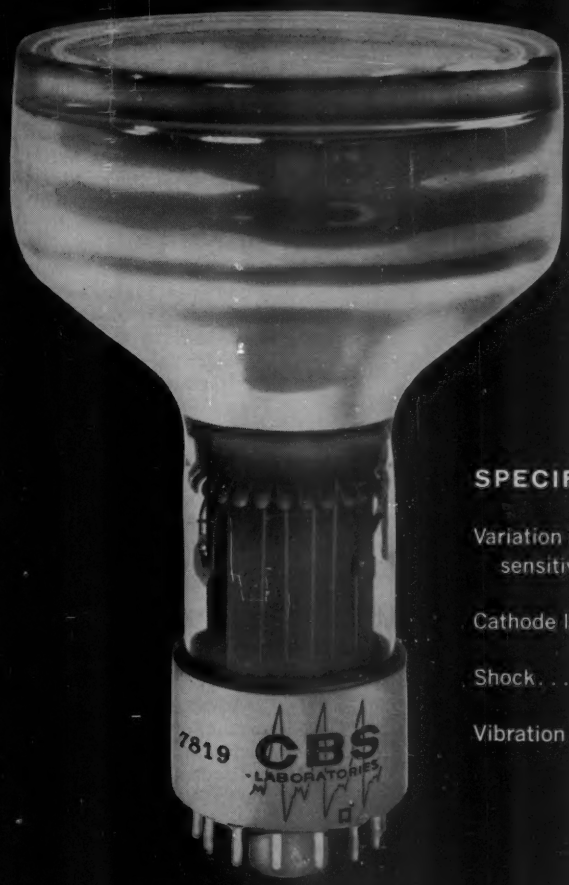

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W. H. OLDENDORF
Veterans Administration Center, Los Angeles, California

Food and Flavor

Concerning the report on radiation flavor by M. P. Drake, B. J. Kroll, and F. J. Pilgrim [*Science* **132**, 1394 (11 Nov. 1960)], may I suggest that the "representative tasting panel" whose responses might enable us to foretell something about "consumer acceptance" be augmented by such invaluable members as a cat and a rook (or any other member of the raven family). In my experience these animals, if copiously supplied with food and given an *embarras de choix*, turn into finical connoisseurs. And, whatever their prejudices may be, there can be no question of partiality against radiation.

Advanced efforts in food technology remind one that ours is a period of transition from mass-produced, mass-distributed, and prefabricated foods toward worse to come. Would it perhaps be desirable, for the benefit of later generations of scientists bound to take an interest in the nature of foods so often referred to in documents of all times up to the present, to stow away a representative selection from all over the world in some remote corner of the Antarctic?

H. GLOOR
Department of Genetics, University of Leiden, Leiden, Netherlands

The Future of "American Men of Science"

American Men of Science has been published as a biographical directory since 1906. As editor, I have carried on its publication for the last 35 years.

During this period the directory has never had financial help in the form of a grant, though it is a marginal publication insofar as profits are concerned. In 1948, after World War II, prices spiraled, making it necessary to ask those included to help make ends meet. The results were gratifying, and through such contributions publication of *American Men of Science* was continued.

I find it desirable to again approach those included for additional funds. The price of the four volumes that cover the physical and biological sciences is high for an individual; after test mailings of the A–E volume, the number of

orders did not come up to the expected percentage. As a result, the size of the complete edition will be smaller than had been planned, and the cost per volume will be correspondingly higher. Thus, the membership subscription established for this edition appears to have been too low.

A request for contributions to make up this deficit has been mailed to those included, or scheduled for inclusion, in the 10th edition (the editors hope that no supplementary contributions will be needed for future editions). It is well known that subscriptions and contributions have never been factors in the selection of scientists to be included in *American Men of Science*.

It has been proposed by a large proportion of those who have returned their proofs that specialized volumes be published. This may be the solution.

I would be glad to receive suggestions from readers of *Science* as to the best method to be followed in future publication of this important tool of the scientists of America.

JAQUES CATTELL*
"American Men of Science,"
Arizona State University, Tempe
* Deceased

Science Teaching

The recent letter on science teaching [*Science* **132**, 836 (23 Sept. 1960)] by Harry Milgrom made reference to an earlier report by Howard E. Gruber [*ibid.* **132**, 467 (19 Aug. 1960)]. Both were stimulating and informative. Each points up a real problem in the area of higher education in the United States (particularly in science education) and the need to re-examine not alone what we are teaching but the pre-service and graduate training we are giving those who have chosen teaching as a career.

We think it ridiculous to teach scientific facts as isolated units of knowledge, but a cursory study of most college examinations indicates that the measurement of factual knowledge is the primary objective. There is much talk in academic meetings about the development and use of the scientific method and the scientific attitude, but there seems to be little attempt to attain these objectives through our present traditional methods of teaching and evaluating.

Jerome Bruner, in a little book called *The Process of Education*, has spoken well of this dilemma in present-day teaching and refers to the teaching of "unconnected facts having a pitiably short half-life in memory."

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more than a series of unrelated courses capped with a research paper or a thesis. It should include a well-articulated program of scope and depth in general and professional education. College teachers who prepare secondary school science teachers need to know something about the problems of secondary school science teaching, and the graduate schools that prepare college teachers of science need to have some idea of science teaching in small colleges.

My thinking has been similar to Gruber's in that I think the history leading up to a scientific discovery and the consequences of such a discovery are important in science teaching. How and where would a student get the background in the history of science for this kind of teaching? Possibly through leisure reading, for there is limited chance for him to receive such training as a required part of his preparation for teaching.

In 1957 I made a random sample of 135 colleges and universities to find to what extent the history and philosophy of science were being offered as a requirement or an elective for those going into teaching. A summary of the compiled data looks as follows: Of the 107 colleges and universities that answered the questionnaire, 58, representing 54.1 percent, answered that they did not include in their curriculum in any form whatever a course directly or indirectly connected with the teaching of the history of science. Ten of the schools included the course in both the department of history and the department of philosophy. In all except four of the institutions the course was at the undergraduate level, and in every instance except two the subject was listed as an elective.

My contention is not that a specific course will be just the answer to problems dealing with the broad background and development of ideas in the sciences, but few will argue that one's scientific education and potentials as a teacher would not be enriched if this and similar disciplines were a part of his required preparation.

In the light of my findings (*1*) I think there is need for more inquiry into what teachers are being trained to teach. This is of real concern to both colleges and secondary schools. We will then be moving in the direction of improving the quality of science instruction.

R. H. SIMMONS
Albany State College, Albany, Georgia

Reference

1. R. H. Simmons, *Sci. Educ.* **41**, No. 1 (1957).

Racial Differences

I have often wondered why some scientists (like other people) are prone to take extreme positions on a subject when there is a logical mid-ground which comes closer to the essential truth. A case in point is the letter by H. E. Garrett [*Science* **132**, 685 (1960)] taking *Science* to task for the news article entitled "Un-American science" [*Science* **132**, 24 (1960)]. It is probably true, as suggested by Garrett, that "equalitarian dogma" regarding racial differences has been too widely accepted as a basic premise. It is also probably true that this has hindered research in this field. To suggest that research in racial differences is "Un-American science" is certainly unscientific. On the other hand, to infer that any proven differences should have any effect on social treatment of the Negro (or any other race) is immoral, ridiculous, and utterly opposed to Jeffersonian equality.

The truth of the matter is that races of men do differ; else they would not be races. These differences almost certainly extend to mental as well as physical traits, just as in the case of individual people. The normal distribution curves for a particular inherent mental characteristic for different races of men would surely be different, just as the curves would differ between

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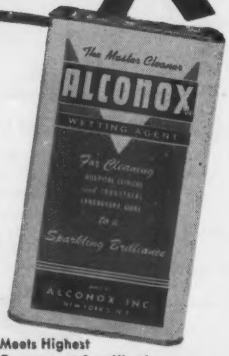

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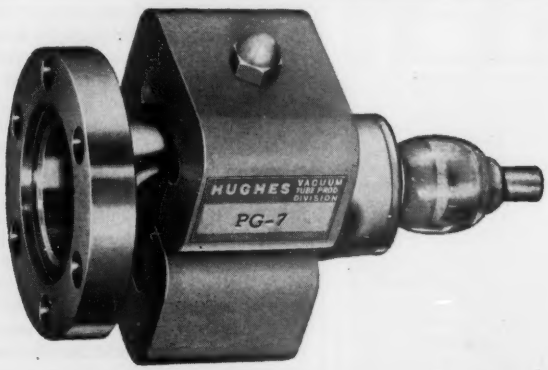

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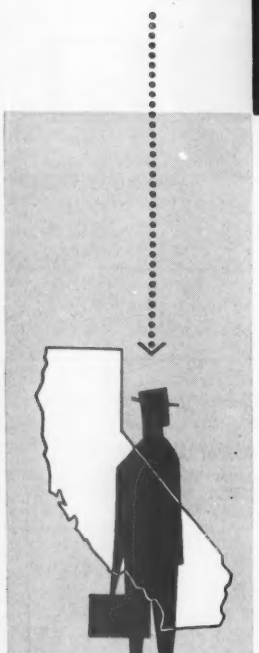

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populations of laborers and college teachers. However, these distribution curves would overlap and, furthermore, would differ for different traits. For example, there may be a higher percentage of Negroes than Scots with an inherent acute sense of rhythm. In a statistical sense U.S. Negroes apparently have greater ability than whites in short-distance running and some other athletic events. In some other traits the shape of the normal distribution curve for the two populations would favor whites. In some there would be little or no difference.

Is this view unscientific, un-American, or undemocratic? Conversely, recognition of racial *differences* is no excuse for branding any race as generally *inferior* to any other. Above all, it is no excuse for intolerance or discrimination. It is just as silly to use racial differences as a basis for discrimination as it is to label studies of racial mental differences "un-American science."

LEON S. MINCKLER
Box 760, Carbondale, Illinois

Wave-Riding Dolphins

The very interesting discussion which has recently taken place between Scholander and Hayes concerning the possible ways in which dolphins or porpoises might obtain free rides in the bow waves of ships (*1*) has stimulated me to keep a very close watch for such activities while at sea. This watch has resulted in the accompanying photograph (Fig. 1), which shows a dolphin (probably *Tursiops* sp.) riding motionless with its tail some 15 to 20 centimeters in front of the bow of a small ship moving at a speed of 10 knots.

This photograph was taken from the bow of the 62-foot motor vessel *Capre* at about 2 P.M. on 9 August 1960, in an absolutely flat calm about 20 miles offshore, en route from the town of Gladstone, Queensland, Australia, to Heron Island, in the Capricorn Group of islands at the southern end of the Australian Great Barrier Reef (*2*). A Zeiss Contaflex II camera was used, with Kodachrome film and a shutter speed of 1/125 second.

Shortly before the picture was taken three dolphins of the same species were observed doing the same thing over a period of about 5 minutes. All three would ride at once, the two outboard ones being tipped over on their sides at angles of about 30°.

My observations of these dolphins have led to further consideration of one of the major problems debated by Scholander and Hayes—namely, why, in Scholander's model, the dolphin does

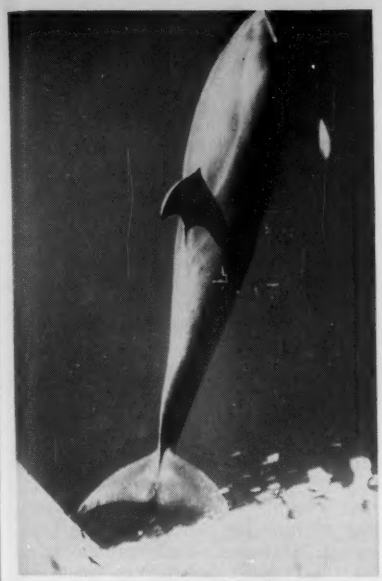

Fig. 1. A dolphin riding the bow wave of a small ship.

not topple over and out of position due to the apparent unbalanced upward force on its tail flukes. In this regard both gentlemen seem to have ignored the fact that dolphins and porpoises also have well-developed pectoral flippers. Might they not adjust the angle of attack of these pectoral flippers so as to produce an upward moment forward of their center of gravity which balances the upward moment from the tail flippers astern? Negative buoyancy, or an orientation of the total-body hydrofoil such as to produce a counteracting downward force, would, of course, be necessary in this situation to prevent the animal's being pushed to the surface.

MALCOLM S. GORDON
Department of Zoology,
University of California, Los Angeles

References and Notes

1. P. F. Scholander, *Science* **129**, 1085 (1959); W. D. Hayes, *ibid.* **130**, 1657 (1959); P. F. Scholander, *ibid.* **130**, 1658 (1959).
2. These observations were made during an expedition supported by U.S. Public Health Service grant No. RG-7114.

Chestnuts

Will you please ask the writers of letters on "The Chinese chestnut" [*Science* **132**, 366 (5 Aug. 1960)] what they really mean by this phrase and the phrase "the American chestnut"? I suspect that the writers are referring to *Castanea dentata* Borph. versus *C. mollissima* Blume, but they do not say so. They leave the reader to finish their work for them.

There are at least ten species of

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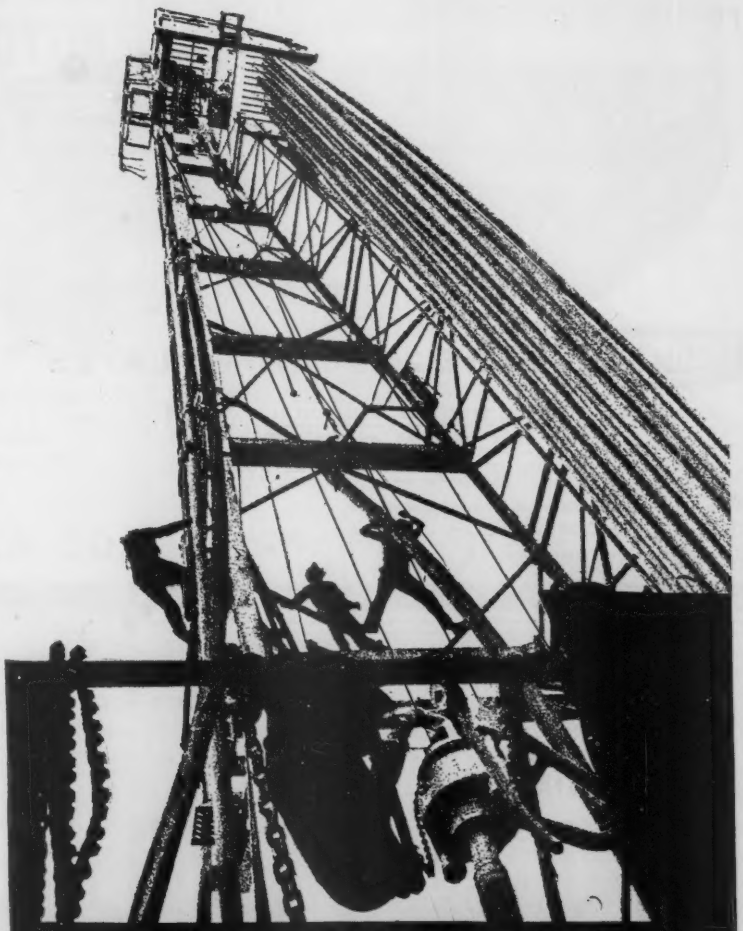

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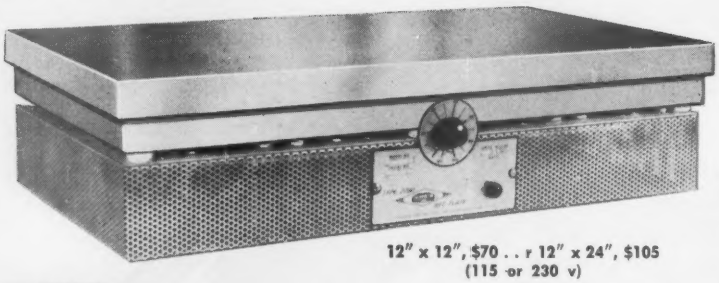

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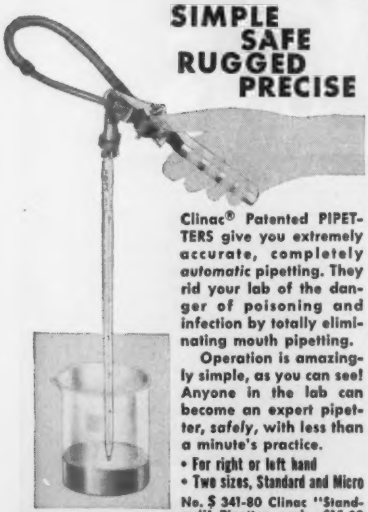

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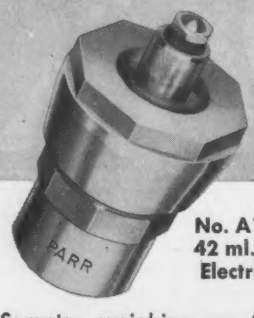

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Castanea Mill., the genus of chestnuts, in the temperate regions of the Northern Hemisphere. Three species occur in China, Japan, and Korea, and there are possibly half a dozen more in the eastern United States. To attempt to distinguish chestnuts as shrubs or trees is scarcely scientifically accurate, as one of the writers shows. In the United States there are several native shrubby chestnuts. One of the writers, incidentally, implies that "the spreading chestnut tree" of Longfellow's poem belonged to the genus *Aesculus* L., possibly *A. hippocastanum* L., instead of *C. dentata*. I agree, but it would be interesting to know whether this is an ascertainable fact.

G. NEVILLE JONES
Department of Botany,
University of Illinois, Urbana

G. Neville Jones is obviously justified in criticizing us for not using Latin names. However, each of us knew what we were referring to when we said "American chestnut" or "Chinese Chestnut." I felt that if I used the Latin names I would be trying to make people think I am a scientist, which I am not. I am just a plain old nut grower who subscribes to a magazine called *Science*.

Regarding Longfellow's chestnut tree, it is not hard to pin it down as a horse chestnut. It was located in Cambridge, Mass., within view of Longfellow's house, and did indeed shelter a blacksmith's shop. The village authorities chopped the tree down in 1876, over the vigorous protests of Longfellow and others. They said it was a menace to those driving under it with heavy loads. My source for that information is *The Horse and Buggy Age in New England* by Edwin Valentine Mitchell.

ROBERT RODALE
"Organic Gardening," Organic Park, Emmaus, Pennsylvania

Hybrids and Growing Practices

In his recent article, "Hybrid corn and the economics of innovation" [*Science*, **132**, 275 (1960)] Griliches treats the use of hybrid seed as if it were an isolated practice. Actually, many practices in proper combination are needed to produce a good corn harvest. True, adapted hybrids have the genetic potential to respond to high levels of plant nutrients and to adequate supplies of soil moisture; yet where these are not present the hybrid has little if any superiority over good old varieties.

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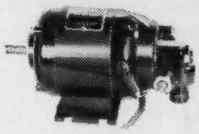

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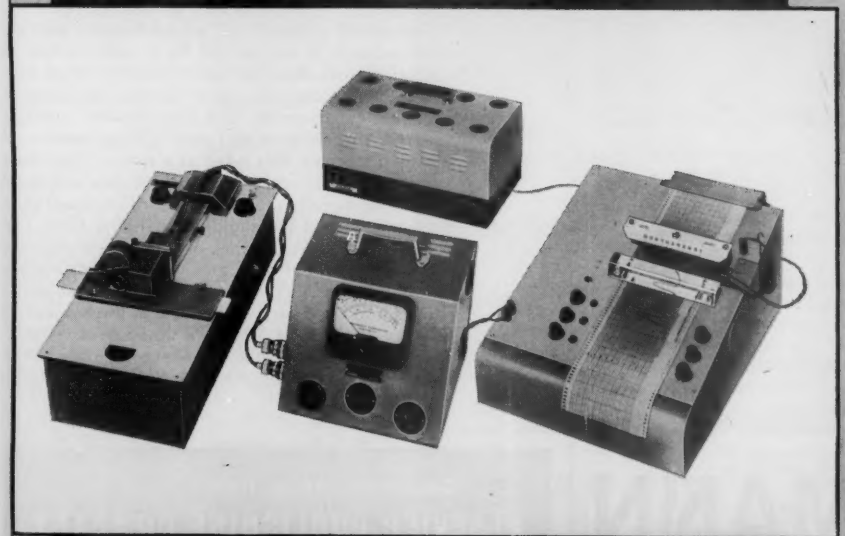

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Fundamental research on atherosclerosis and related subjects is carried out by a wide variety of specialists, including for instance pathological anatomists, physiologists, cardiologists, biochemists and physical chemists, and the resultant publications are therefore spread over a large number of scientific journals. This is felt as a serious hindrance by many investigators who wish to stay informed about new developments and trends of research in different parts of the rapidly expanding field. The publication of the Journal of Atherosclerosis Research is intended as a means of remedying this situation and of helping workers in atherosclerosis research to keep an overall view of the subject.
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CHARLES E. KELLOGG
United States Department of Agriculture, Washington, D.C.

It is impossible in a brief paper to cover *all* the relevant aspects of a problem. The figures and data I used were based on experiments that attempted to hold other cultural practices constant. The interaction aspects brought out in Kellogg's letter are undoubtedly very important, and there was no intention to minimize them. The importance of the increases in the use of fertilizer is recognized and analyzed in my paper on "The demand for fertilizer: An economic interpretation of a technical change" (*J. Farm Economics*, August 1958).

ZVI GRILICHES
National Bureau of Economic Research, New York, New York

Records for Future Historians

The report by Chauncey D. Leake on "Preserving our science archives" [*Science* **132**, 158 (15 July 1960)] concerns a matter deserving greater attention than has been given it by most scientists in the past. When Samuel Henshaw succeeded Alexander Agassiz as director of the Museum of Comparative Zoology at Harvard University, he wrote to E. S. Morse, director of the Peabody Museum of Salem, as follows (*1*): "It is strange that Mr. Agassiz kept so few mementos of the M.C.Z. I have been getting together such data as I can find as to early workers in the museum—I want to leave a good lot of M.C.Z. data for someone if I do not get a chance to use it myself."

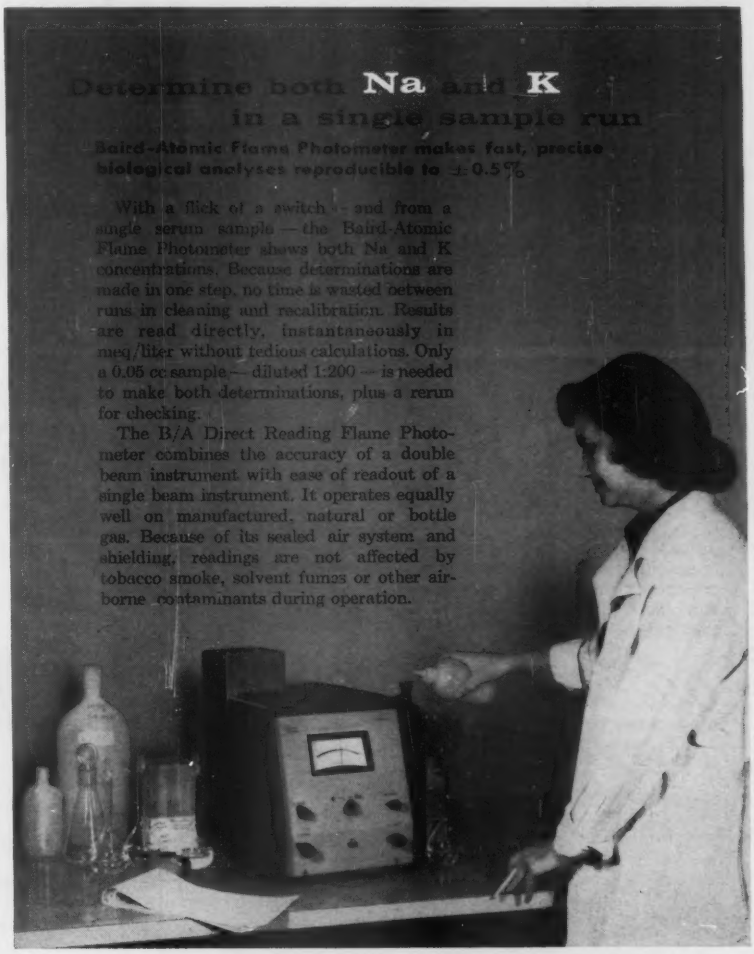
Many scientists do not realize the historical importance of their records. The editorial by Gerald Gruman [*Science* **127**, 1471 (1958)] and the recent conference on science manuscripts reported by Leake pointed up the need for more attention to the historical aspects of science. Over 40 years ago T. D. A. Cockerell at the University of Colorado wrote to Morse as follows (*1*): "I wish we had some systematic way of preserving data on American Science. At the New York Botanical Garden they have a good plan. For each American Botanist they have a large, open envelope or folder into which can be stuffed any letter, Ms., portrait or whatnot. Thus all sorts of data accumulate and will some day be very handy for the historian of American Botany—what a blessing it would be if naturalists habitually filed somewhere, brief accounts of all their collecting expeditions."

A few years ago a national committee of the International Union of the History and Philosophy of Science was formed [*Science* **127**, 1166 (1958)]. The Academy Conference has a Committee on History of Science, and many state academies have academy historians. What is urgently needed is a more general awareness on the part of scientific workers of the need to preserve personal and professional records for our future historians of science.

RALPH W. DEXTER
Department of Biology, Kent State University, Kent, Ohio

Note

1. The letters quoted in this communication are on file at the Peabody Museum of Salem, Mass., and are quoted with the permission of Ernest S. Dodge, director of the museum.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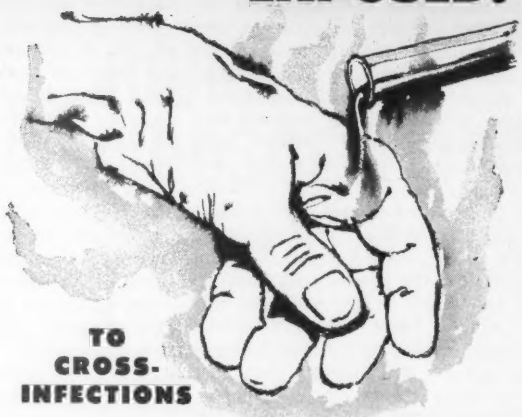

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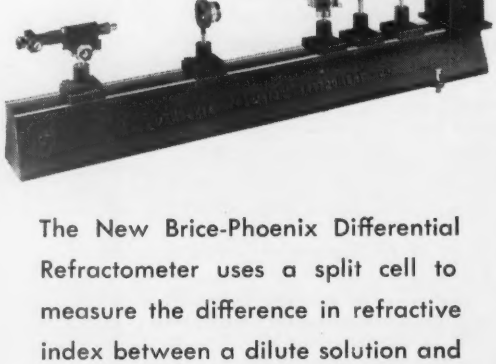

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Meetings

Science News Writing

"Learning without thinking is useless. Thinking without learning is dangerous." So wrote Confucious about 500 B.C. Concern regarding this precept prompted the National Science Foundation to underwrite costs covering six science-news-writing seminars and conferences during 1960. These conferences were held in the following localities: Chapel Hill, North Carolina; Louisville, Kentucky; New York City; Fort Collins, Colorado; Manhattan, Kansas; and northern Minnesota.

The Science News Writing Seminar held at Colorado State University in Fort Collins from 12 to 18 September was sponsored by the Denver *Post*, the Boulder Laboratories of the National Bureau of Standards, and Colorado State University. Herman Weisman of Colorado State University was seminar director; Mortimer Stern of the Denver *Post* and David M. Gates of the National Bureau of Standards were associate directors. Participation was limited to 25 science reporters, primarily from a 15-state region centered on Colorado, although several came from other parts of the United States. In addition to the science news writers in attendance, another dozen individuals in the field of communications attended sporadically, and some 20 scientists participated in one or more of the sessions.

The seminar program was arranged so that the scientists expressed their views on science, education, and science news writing early in the week. The science news writers presented their problems, attitudes, and objectives later in the week, and the final session consisted of replies and a summing up by both groups. Three basic questions represented the framework for the seminar: What is going on in the exploding world of science? How best can reporters tap the sources of scientific information? How can science news stories best be told to newspaper readers?

Keynote addresses were given by Palmer Hoyt, editor and publisher of the Denver *Post*, and Frederick W. Brown, director of the Boulder Laboratories of the National Bureau of Standards. Other addresses given during the seminar were by Theodore Puck, professor of biophysics, University of Colorado; John M. Parker, Rocky Mountain district manager of the Kirby Petroleum Co.; Henry Eyring, dean of the Graduate School, University of Utah; and Graham DuShane, editor of *Science*. Panel discussions were held on the following subjects: "Philosophy of Scientific Research," "Biology Research," "Soil and Water Research," "Science Writing," "Science News Writing," and "The Scientists Talk Back."

Speakers on the panels were as follows: William E. Morgan (president, Colorado State University); M. L. Albertson (director, Colorado State University Research Foundation); Robert V. Bartz (executive director, Associated Rocky Mountain Universities); S. I. Johnson (director, Denver Research Institute); William Purdy (director of engineering, the Martin Company, Denver); Willard C. Haselbush (Denver *Post*); Gene Lindberg (Denver *Post*); Richard E. Slawsky (New York *World-Telegram and Sun*); Arthur J. Snider (Chicago *Daily News*); Lawrence Durrell (dean emeritus, Colorado State University, College of Arts and Sciences); Rue Jensen (dean, Colorado State University, College of Veterinary Medicine); John R. Olive (American Institute of Biological Sciences); Frank Salisbury (Colorado State University); Verne L. Van Breeman (Mercy Hospital, Denver); Watson Davis (director, Science Service); H. J. Geiger (Harvard Medical School); Harold F. Osborne (American Institute of Biological Sciences); Daniel Q. Posin (DePaul University); A. R. Chamberlain (vice president, Colorado State University); Robert Dils (Colorado State University, College of Forestry); Omar J. Kelley (U.S. Department of Agriculture); Herbert Riehl (Colorado State University); and Robert Whitney (Colorado State University).

The participants spent one day at the Boulder Laboratories of the National Bureau of Standards. They also visited the High Altitude Observatory of the University of Colorado, with

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Robert J. Low, executive officer, leading the tour. There was a half-day excursion into the Rocky Mountains, which included a visit to the National Bureau of Standards' Fritz Peak Observatory, directed by Franklin E. Roach. Each evening the sessions were continued informally, and discussion ran into the night. At week's end the participants were weary, enlightened, and still friends, despite the fact that the gap between the two professional groups had been large indeed at the beginning of the seminar. Much of the success of the seminar was due to the pleasant and efficient handling of the rigorous 14-hour day, six-day schedule.

Specific answers formulated at the Fort Collins meeting to the question, How can science news stories best be told to newspaper readers? and comments relating to the whole subject of science news writing were as follows:

1) An outstanding science reporter must first be an excellent reporter. The best possible science reporter is a true hybrid, a real journalist and a real scientist.

2) There is a lack of aggressiveness in science writing; reporters are not skeptical enough about handouts, are timid in their presentation, and seldom do interpretive writing based on a careful background study of the subject matter.

3) A science reporter should know and use a "stable of experts"—that is, he should have a friend in each of the major scientific disciplines on whom he can call for advice.

4) There is little coverage of basic research and almost no coverage of negative experiments and research projects. The public should be educated in the philosophy of science and should understand that some experiments and projects, both basic and applied, are failures. Since a large part of what the public learns is from our daily newspapers and since the public is paying very directly for most of the research going on today, it is obvious that taxpayers, legislators, and all people concerned with formulating and administering educational and research programs must have a deeper understanding of science.

5) Newspapers have too many "sacred cows" of both the inclusive and the exclusive variety. For example, there is prodigious coverage of sports despite the fact that reader surveys show that science news stories are read by approximately twice as many people as stories on sports; newspapers exclude critical and analytical reporting of technological or applied science if such stories cover one of the local sacred minorities, such as the lead-zinc lobby group or the western reclamation lobby group.

6) Too many stories promise a

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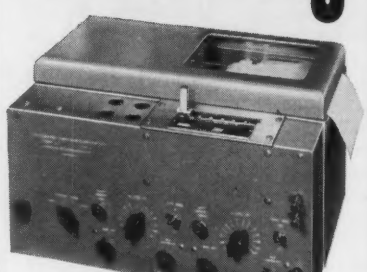

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"breakthrough." This leads people to think that science evolves primarily around breakthroughs, and breakthroughs for a specific purpose, such as the control of cancer and heart disease. Further, in regard to medical stories, statistical results are sometimes accepted willy-nilly from scientists and medical men who may not qualify or properly limit the conclusions based on statistical data.

7) There is little coverage of the social sciences.

8) Being a good reporter and a good writer is not enough. A reporter must continue to educate himself in order to advance his knowledge of science. A science reporter should seek the opportunity to work in a laboratory or in the geological department of an oil company or to attend a field camp in session in order to get the "feel" of scientific investigation. This period should be at least a week and preferably a month or more, and it should be repeated. A medical reporter should make the round of the wards with an intern once every six months.

9) The "lead concept" is not necessarily the best way to tell a science news story.

10) The wire services and some newspapers at times arbitrarily limit science news stories to 150 words.

11) Managing editors wrongly think everyone can cover everything.

12) Poor techniques are frequently used in telling a science story of the expository type. The correct techniques are as follows: (i) Use graphic aids (pictures, diagrams, sketches, cartoons, and good pictures); (ii) keep the development slow, do not amaze; explain, teach, have a logical re-enactment, build up to a climax; (iii) don't use technical jargon unduly, but be willing to introduce new words to the public when necessary; (iv) write to one person—*yourself*.

The reporters had some specific and appropriate things to say to scientists.

1) The scientist should be willing to cooperate with the press and society.

2) The scientist should have a better concept of the public that is to be informed. Scientists work with things. Reporters know about and write for people. The reporter's reader cannot be told what to read. If a science writer can convey the excitement of science he will get and hold the attention of the reader. The excitement factor is most important since newspapers, to be successful, must be read, and therefore a newspaper must appeal to both intellect and emotion.

3) The scientist should be willing to interpret his subject for the layman.

4) The scientist should realize that a reporter works with a deadline, not only on straight news stories but also on feature stories.

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5) Newspapers contribute to civic projects, and they need more help from scientists than they are getting at the present time. In the opinion of the science news writers this is particularly true with regard to crusades to raise teaching standards and teachers' salaries, wherein scientists, both as individuals and as groups, could work with the press better than they now do. Scientists appear not to accept enough public responsibility.

6) Scientists should realize that newspapers must crusade for 200 different things, of which science is only one.

7) Universities give very few honorary degrees to scientists in basic research; this shows poor judgment on the part of the university and is bad public policy.

8) There is a common tie between scientists and reporters; both are curious and both are skeptical.

The 20 points listed above are representative of the general consensus of the Fort Collins meeting. Individual reactions and interpretations on these points varied widely among the reporters and the scientists present, but the general feeling was clear.

It was evident from the Fort Collins meeting that editors and publishers must be convinced of the need for improving the quality and quantity of science news reporting. We urge *Editor and Publisher*, the National Science Foundation, and any other interested group to sponsor science reporting seminars limited to editors, publishers, and scientists.

We believe that some specific steps are in order. Presidents of scientific societies should stress the fact, in letters and in conversation with newspaper publishers, that our country needs better coverage of basic science news and research. Local scientific societies should assist with public-school reforms and projects of similar nonpartisan nature. Local or national scientific groups should not become involved in group endorsement of partisan political activities, but it is important that the consensus of professional opinion, within a scientific organization, concerning a specific issue be made known to the public through the press. Concerning nonpartisan issues, very few scientific societies avail themselves of the "poll" type of survey. If a legitimate poll is made (by a nonmember) of the membership of a scientific organization, such a poll is news for the local press and is also an effective means of influencing public opinion.

On a national level, related scientific disciplines need umbrella-type organizations in order to maintain effective professional responsibility, ethics committees, public information offices, school curricula committees, and the like. Several organizations of this type exist and are doing a good job. We believe that these organizations should be supported and strengthened.

Science, the organ of the oldest and largest of the umbrella-type associations in this country, published the following pertinent items in 1960 on the subject of science news writing and related topics: "Science reporting—today and tomorrow," by Joan Troan [**131**, 1193 (1960)]; "Dons or crooners?" by Eric Ashby [**131**, 1165 (1960)]; "Popularization of science," by Jean Rostand [**131**, 1491 (1960)]; "Science and human welfare" [**132**, 68 (1960)] and "Science teachers and the scientific attitude: An appraisal of an academic year institute," by Howard E. Gruber [**132**, 467 (1960)].

Nothing new regarding science news writing and scientists was said at Fort Collins, but the inspiration, the impact, and the results are new. Reporters and scientists agreed unanimously as to the tremendous value to be gained from conferences of this type and urged that other such conferences be convened in the future to further understanding between the two professions.

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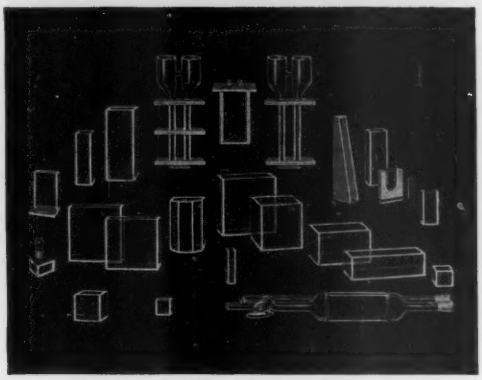

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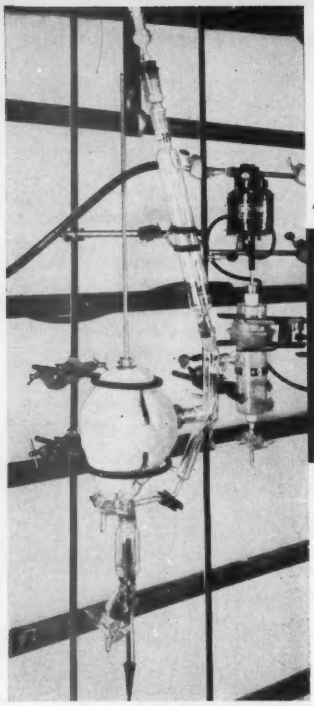

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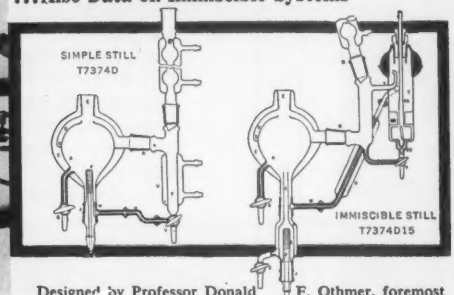

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*Othmer, D. F., Gilmont, R. and Conti, J. J. Ind. Eng. Chem. 52, 625 (1960) Reprints furnished on request.

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Physiological and Behavioral Aspects of Taste

Obesity and selection of a nutritionally adequate diet are human problems in many societies today. Restricted intake of feed has been established as advantageous to animal production and health. Various animals show deficiency-related specific appetites. In addition, gustatory stimuli can be powerful motivators for learning. The complex nature of the problems which the field of "taste" encompasses suggests that an interdisciplinary approach would provide wider perspective. On 27 and 28 June 1960, a Conference on Physiological and Behavioral Aspects of Taste, organized with the support of the National Science Foundation, was held at Cornell University.

The concept of senses was traced from its origin in Aristotelian philosophy by R. B. MacLeod. He argued: "There is no such thing as a sense." Rather, "We have dimensions and qualities of sensations, and these can be measured. . . . We [should] stop talking about taste and smell, audition and hearing as sensory systems, . . . look first at the dimensions of human sensory experience and then try to identify their neurological, their physiological, their anatomical, and their physical correlates." This questioning of a rigid categorization of sensory input into the usual modalities or senses was partially supported by neurophysiological data.

Human judgments of pair-mixtures of sodium chloride, citric acid, sucrose, and caffeine were reported by F. J. Pilgrim. Interactions were complex, with chemical composition and concentration of each component significant. The words *sour* and *bitter* were sometimes used interchangeably in describing these stimuli. Similar "quality confusion" was reported by R. M. Pangborn. In the light of these observations and other data, T. Engen questioned the validity of the classical four taste qualities.

In studying species differences in taste preference behavior, it is necessary to be free of preconceived ideas as to what chemical entities will be selected or rejected by each species. On the bases of several thousand trials with calves, pigs, chickens, and other animals it was obvious that man cannot use his taste reactions to predict the taste reaction of an animal. The unique individual taste behaviors described by M. R. Kare could not be related to any of a large group of physical or chemical variables incorporated into a systematic study. Further, the dozen taste buds in the fowl or the 25,000 in the ruminant could not be correlated with the distinctive taste behaviors of these two species. These data generally served to complement

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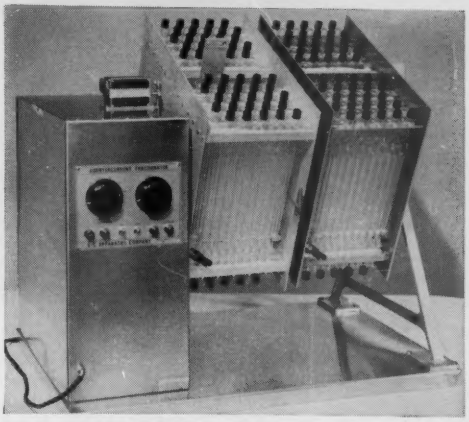

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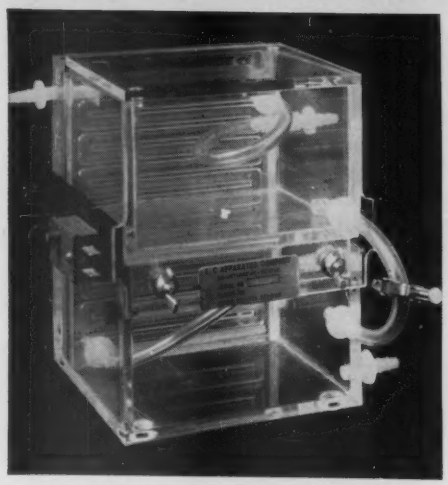

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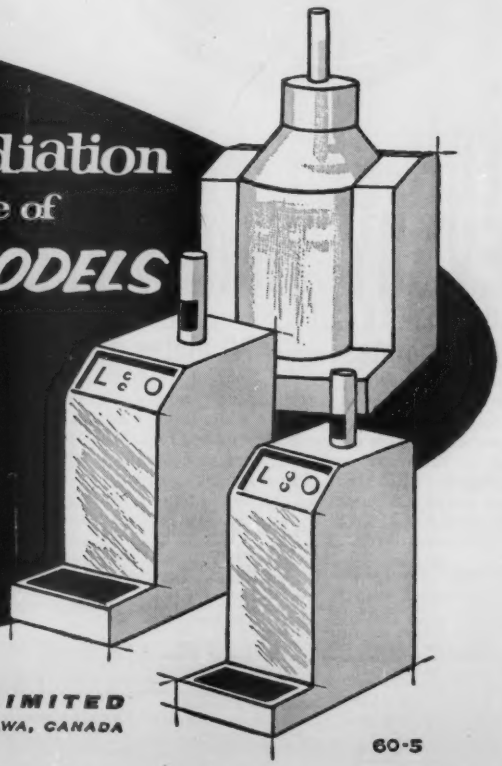

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the comparative studies of A. J. Carpenter.

Related electrophysiological data on chorda tympani and glossopharyngeal responses in chickens, goats, sheep, cats, monkeys, and human beings were reported by R. L. Kitchell. No two of these animals showed the same overall neural response pattern for the stimuli used.

Calves, rats, rabbits, and hamsters on adequate *ad libitum* diets will select a range of sucrose (glucose) solutions when offered a sucrose (glucose)-water choice. The relation between intake and sucrose (glucose) concentration is a function of the length of exposure to the choice situation: When both fluids are constantly available for approximately 24 hours, the preference function is roughly bell-shaped, with the maximum at about 10 percent (0.3*M*) sucrose. A choice period of 20 minutes or less results in a roughly linear and positive function. Postingestional factors, including all effects of the ingested material except the direct stimulation of taste receptors, are thought to underlie the differences. The osmotic dehydration effects of the ingesta have been emphasized in current research.

Experiments involving stomach loads, designed to test the osmotic dehydration hypothesis, were reported by H. L. Jacobs. In a 6-hour, two-choice situation, hypertonic glucose loads in nonwater-deprived rats did not affect water intake, while water deprivation (16 hours), with or without glucose loads, significantly increased water intake. Glucose intake was reduced only by hypertonic glucose loads.

The location and functional characteristics of the thalamic gustatory relay in the rat were described by G. P. Frommer. Multiunit recording and adequate stimulation, combined with histological verification of electrode tracks, localized thalamic gustatory input in the medial portion of the tongue-like medial extension of the nucleus ventralis [according to DeGroot's terminology, *Trans. Roy. Netherlands Acad. Sci.* **52** (1959)]. Tactile and temperature inputs were localized laterally in the subnucleus. Thalamic response patterns were similar to those described in the chorda tympani (C. Pfaffmann) and in the medulla (B. P. Halpern).

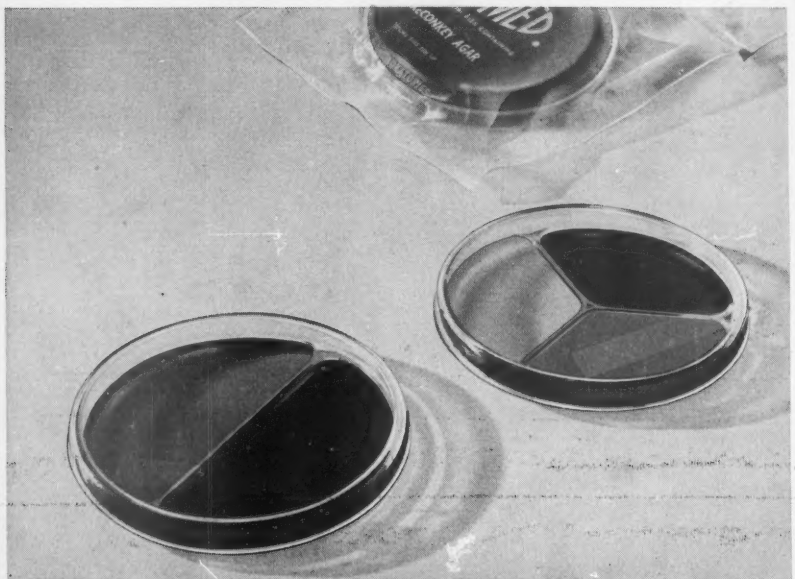
This localization of the thalamic gustatory relay and the limited overlap of taste and somesthetic regions were verified by a series of lesion and recording studies described by R. M. Benjamin.

The procedures used in electrophysiological studies of neural responses to taste stimuli were discussed by R. L. Kitchell. Pre-stimulus treatment, solvent, temperature, method of applying fluids to the tongue, procedures for gaining access to the recording site, and electronic apparatus were all significant factors.

The development of brief-exposure preference testing methods (by P. T. Young) and data collected with an electronic preference tester were presented by K. Christensen. Sodium chloride-sucrose mixtures as acceptable as one of a series of pure sucrose solutions were determined for the rat on an *ad libitum* food and water regimen; for example, a 1-percent (0.03*M*) sucrose solution was matched by a 0.5-percent (0.1*M*) sodium chloride, 0.5-percent (0.015*M*) sucrose mixture.

Interactions between taste-determined behavior, nutritional state, and metabolic activity were discussed by J. Tepperman. Changes in any one of these may lead to alterations in the other two. The experiments of C. P. Richter were quoted as classic examples of these interactions. Recent experiments have demonstrated that modification of rate of lipogenesis, of catabolism of fatty acids, and of enzyme production can be a function of the metabolic mixture. Taste can determine the nature of the metabolic mixture.

A detailed example of interaction



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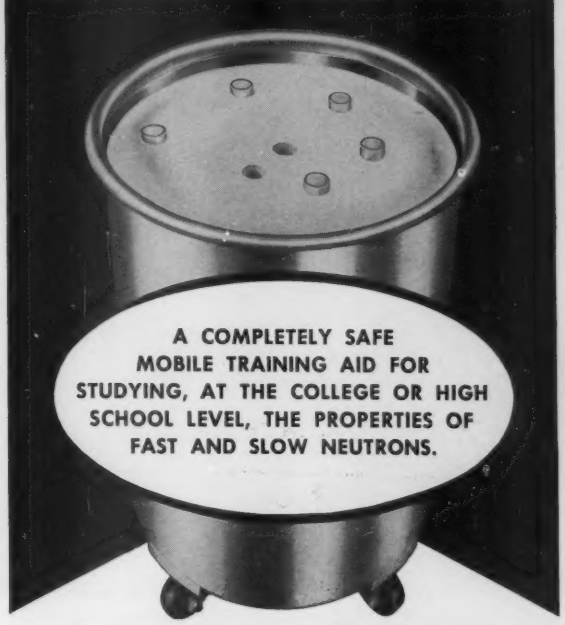

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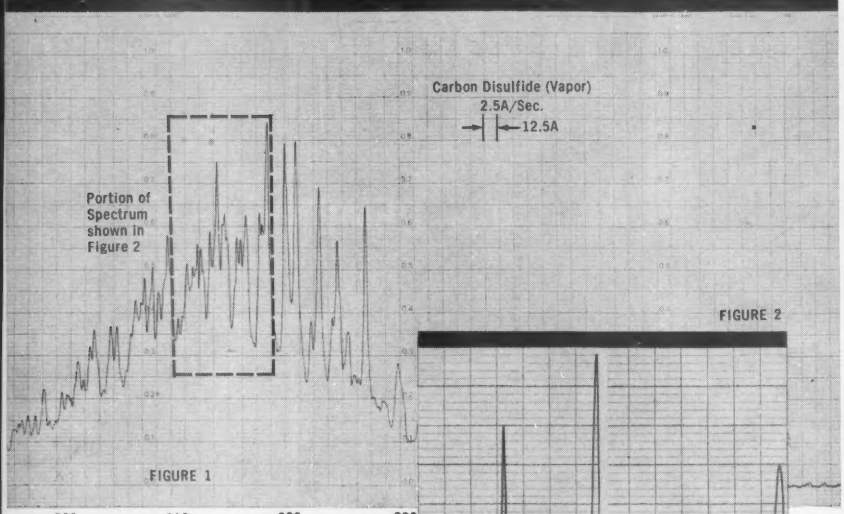

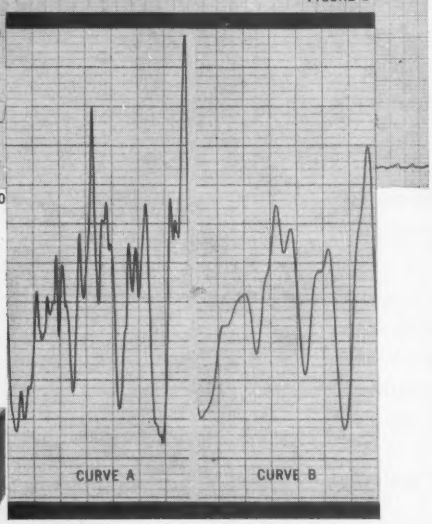

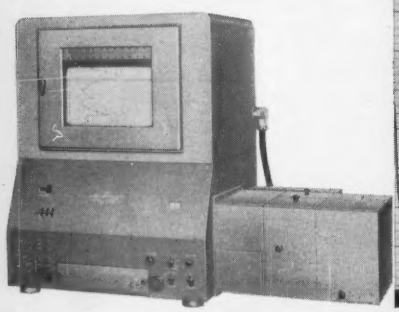

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between quality and quantity of ingested food and metabolism was presented by F. W. Heggeness. Weanling rats fed high carbohydrate diets ingested calories in excess of requirements and developed a transient, self-limiting elevation in metabolism. This could be prevented by initially presenting the diets in amounts just sufficient to maintain body weight. Modification of capacity for lipogenesis appeared to be the critical factor.

The 1960 Conference on Physiological and Behavioral Aspects of Taste brought together researchers from many disciplines: L. M. Bartlett (zoology), University of Massachusetts; R. M. Benjamin (physiology), University of Wisconsin; J. A. Carpenter (applied biodynamics), Yale; K. Christensen (psychology), University of Illinois; W. C. Dilger (ornithology), Cornell; T. Engen (psychology), Brown; I. Y. Fishman (biology), Grinnell; G. P. Frommer (psychology), Brown; A. Goldstein (psychology), Cornell; E. B. Hale (poultry husbandry and psychology), Pennsylvania State; A. E. Harriman (psychology), Franklin and Marshall; F. W. Heggeness (physiology), University of Rochester; H. L. Jacobs (physiology and psychology), University of Rochester; R. L. Kitchell (anatomy), University of Minnesota; R. B. MacLeod (psychology), Cornell; G. R. Morrison (psychology), McMaster; R. M. Pangborn (food technology), University of California; F. J. Pilgrim (food acceptance), Quartermaster Institute; M. W. Schein (poultry husbandry), Pennsylvania State; J. Tepperman (pharmacology), State University of New York, Upstate Medical Center; and L. F. Titlebaum (nutrition), Harvard.

The conference proceedings were recorded. An edited version is being prepared for publication.

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Forthcoming Events

February

1–3. Solid Propellant Rocket Conf., American Rocket Soc., Salt Lake City, Utah. (R. D. Geckler, Aerojet-General Corp., P.O. Box 1947, Sacramento, Calif.)

1–3. Winter Military Electronics Conv., 2nd, Inst. of Radio Engineers, Los Angeles, Calif. (A. N. Curtiss, IRE Business Office, 1435 S. La Cienega Blvd., Los Angeles 35)

1–4. American Physical Soc., annual, New York, N.Y. (K. K. Darrow, APS, 538 W. 120 St., New York 27)

2–4. Congress on Administration, 4th annual, Chicago, Ill. (R. E. Brown, Amer-

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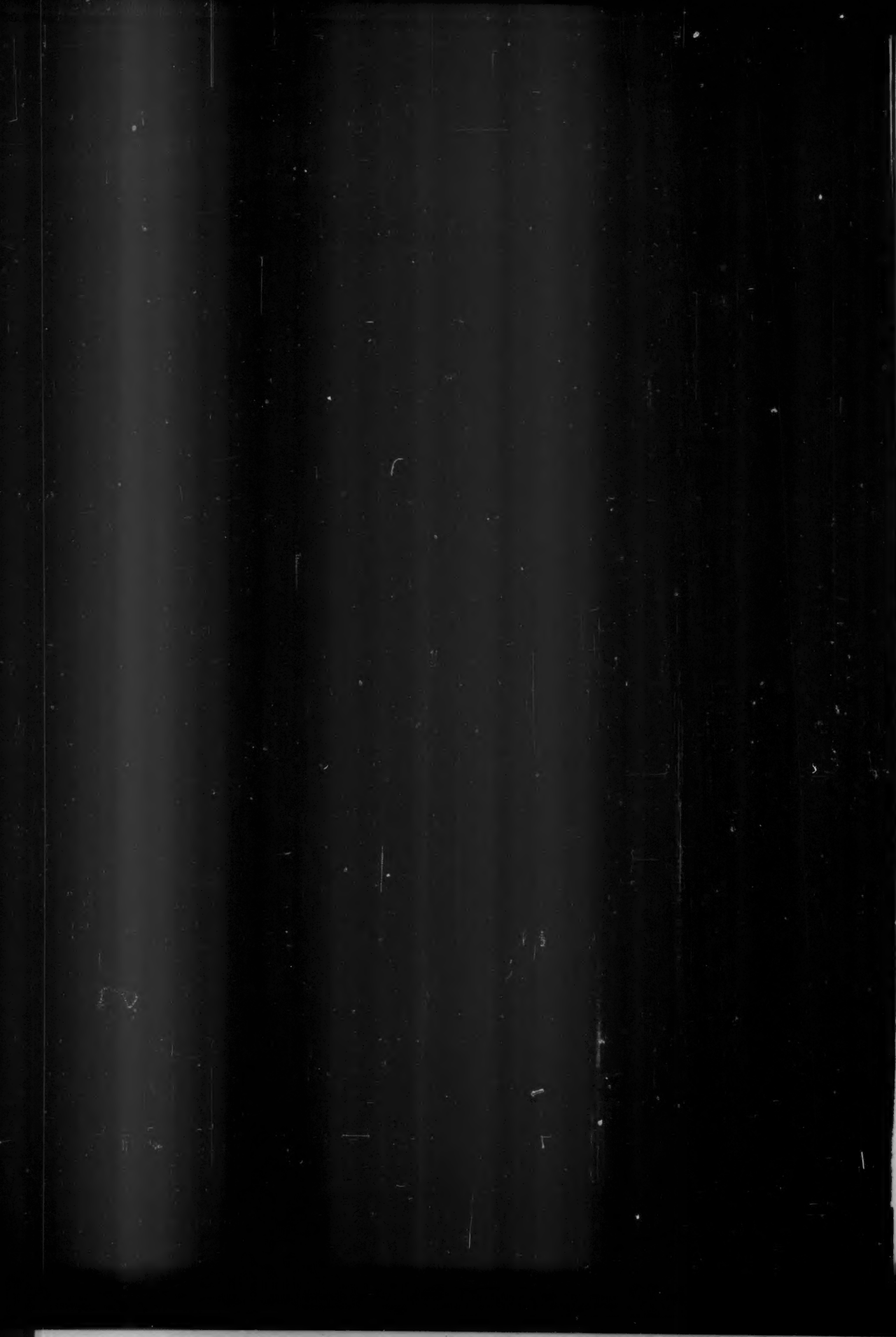

ican College of Hospital Administrators, 840 N. Lake Shore Dr., Chicago 11)

6–8. American Acad. of Allergy, 17th annual, Washington, D.C. (J. O. Kelly, 756 N. Milwaukee St., Milwaukee 2, Wis.)

6–8. Geodesy in the Space Age, symp., Ohio State Univ., Columbus. (W. A. Heiskanen, Ohio State Univ., 1314 Kinnear Road, Columbus 12)

6–10. British Medical Assoc., annual, Auckland, New Zealand (E. Grey-Turner, B.M.A., Tavistock Sq., London, W.C.1)

9–15. Second Allergy Conf., Nassau, Bahamas. (I. M. Wechsler, P.O. Box 1454, Nassau)

13–16. American Soc. of Heating, Refrigerating and Air-Conditioning Engineers, Chicago, Ill. (R. C. Cross, 234 Fifth Ave., New York 1)

14–15. Conference on Microdosimetry, 2nd, Rochester, N.Y. (N. Kreidl, Bausch & Lomb Optical Co., Inc., Rochester 2)

15–17. International Solid-State Circuits Conf., Philadelphia, Pa. (J. J. Suran, Bldg. 3, Room 115, General Electric Co., Electronics Park, Syracuse, N.Y.)

16–18. Biophysical Soc., annual, St. Louis, Mo. (W. Sleator, Dept. of Physiology, Washington Univ., St. Louis 10)

22–25. American Educational Research Assoc., annual, Chicago. Ill. (G. T. Buswell, 1201 16th St., NW, Washington 6)

23–25. Fifteenth Annual Symp. on Fundamental Cancer Research, Houston, Tex. (Publications Dept., Univ. of Texas M.D. Anderson Hospital and Tumor Inst., Texas Medical Center, Houston 25)

23–25. Symposium on Molecular Basis of Neoplasia, Houston, Tex. (Publications Dept., Texas Medical Center, Houston 25)

26–1. American Inst. of Chemical Engineers, natl., New Orleans, La. (F. J. Van Antwerpen, AICHE, 25 W. 45 St., New York 36)

26–2. American Inst. of Mining, Metallurgical, and Petroleum Engineers, annual, St. Louis, Mo. (AIME, 29 W. 39 St., New York 18)

27–3. Conference on Analytical Chemistry and Applied Spectroscopy, 12th, Pittsburgh, Pa. (L. P. Melnich, U.S. Steel Corp., Monroeville, Pa.)

March

2–4. Optical Soc. of America, spring meeting, Pittsburgh, Pa. (Miss M. Warga, 1155 16th St., NW, Washington 6, D.C.)

5–9. Gas Turbine Conf. and Products Show, 6th annual, Washington, D.C. (Meetings Dept., American Soc. of Mechanical Engineers, 29 W. 39 St., New York 18)

6–8. North American Wildlife and Natural Resources Conf., 26th, Washington, D.C. (C. R. Gutermuth, Wildlife Management Inst., 709 Wire Bldg., Washington 5)

7–9. American Railway Engineering Assoc., annual, Chicago, Ill. (N. D. Howard, 59 E. Van Buren St., Chicago 5)

8–10. Instrument Soc. of America Conf., 11th annual, Pittsburgh, Pa. (R. R. Webster, 900 Agnew Ave., Pittsburgh 30)

8–11. Neurosurgical Soc. of America, Boca Raton, Fla. (R. K. Thompson, 803 Cathedral St., Baltimore 1, Md.)

9–10. Magnetohydrodynamics, symp. on engineering aspects of, Philadelphia, Pa.

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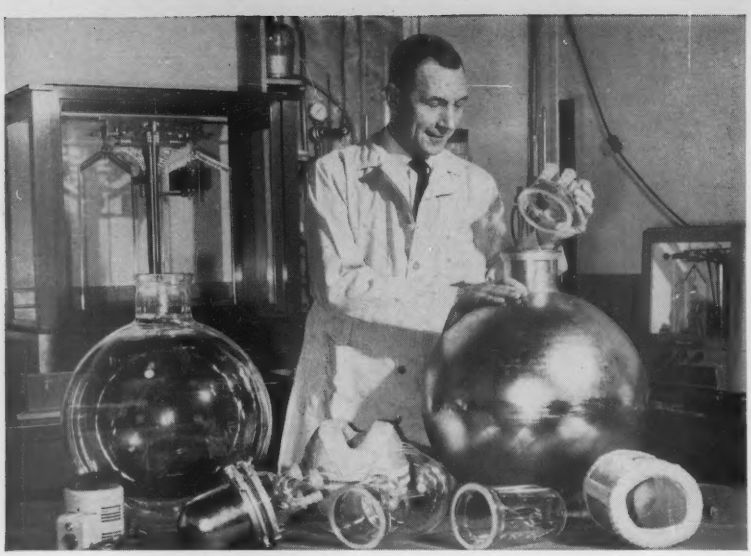

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12–17. American College of Allergists, annual, Dallas, Tex. (P. Gottlieb, 818 Medical Arts Bldg., Philadelphia, Pa.)

13–17. National Assoc. of Corrosion Engineers, annual. Buffalo, N.Y. (W. A. Mapler, 18263 W. McNichols Rd., Detroit 19, Mich.)

13–24. Radiological Health, course in, Cincinnati, Ohio. (Chief, Training Programme, Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati 26)

14–16. Clinico-Pathological Significance of Renal Biopsy, Ciba Foundation symp. (by invitation only), London, England. (Ciba Foundation, 41 Portland Place, London, W.1)

14–16. Inter-Station Supersonic Track Conf., 6th symp., China Lake, Calif. (U.S. Naval Ordnance Test Station, Code 307, China Lake, Calif.)

15–17. Medical Photography and Cinematography, intern. cong., Cologne, Germany. (Deutsche Ges. für Photographie, Neumarkt 49, Cologne)

16–17. Textile Engineering Conf., American Soc. of Mechanical Engineers, Clemson, S.C. (ASME Meetings Dept., 29 W. 39 St, New York 18)

16–18. Aviation/Space Education, 5th natl. conf., Washington, D.C. (Natl. Aviation Education Council, 1025 Connecticut Ave., NW, Washington 6)

17–19. International Medical Conf., Liège, Belgium. (Medical Commission of the FIR, Castellezgasse 35, Vienna II, Austria)

19–25. American Soc. of Photogrammetry, American Cong. on Surveying and Mapping, Washington, D.C. (C. E. Palmer, ASP, 1515 Massachusetts Ave., NW, Washington 5)

20–22. American Physical Soc., Monterey, Calif. (W. A. Nierenberg, Univ. of California, Berkeley 4)

20–23. Institute of Radio Engineers, 1961 intern. convention, New York, N.Y. (E. K. Gannett, IRE, 1 E. 79 St., New York 21)

20–24. American Surgical Assoc., Boca Raton, Fla. (W. A. Altemeier, Cincinnati General Hospital, Cincinnati 29, Ohio)

20–24. National Health Council, forum and annual meeting, New York, N.Y. (NHC, 1790 Broadway, New York 19)

20–24. Western Metal Cong. and Exposition, 12th, Los Angeles, Calif. (A. R. Putnam, American Soc. for Metals, Metals Park, Ohio)

21–23. American Meteorological Soc., general meeting, Chicago, Ill. (E. P. McClain, Dept. of Meteorology, Univ. of Chicago, Chicago 37)

21–23. American Physical Soc., Division of High-Polymer Physics, 21st, Monterey, Calif. (D. W. McCall, Bell Telephone Laboratories, Murray Hill, N.J.)

21–23. American Power Conf., 23rd annual, Chicago, Ill. (W. C. Astley, Philadelphia Electric Co., 900 Sansom St., Philadelphia 5, Pa.)

21–24. American Assoc. of Anatomists, 74th annual, Chicago, Ill. (O. P. Jones, Dept. of Anatomy, Univ. of Buffalo, Buffalo 14, N.Y.)

21–30. American Chemical Soc., 139th, St. Louis, Mo. (A. T. Winstead, ACS, 1155 16th St., NW, Washington 6)

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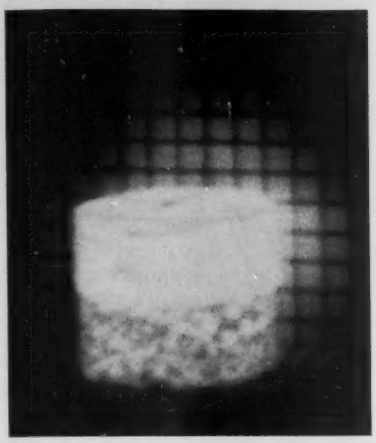

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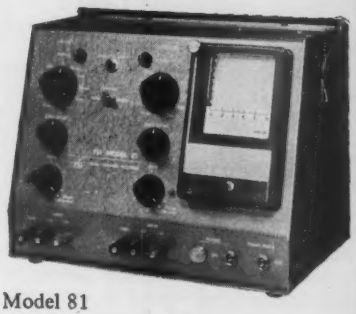

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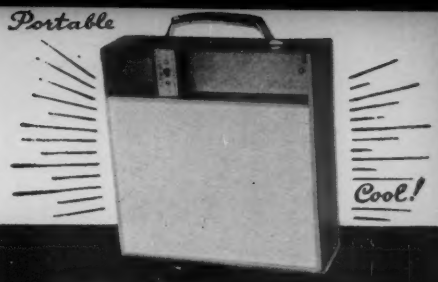

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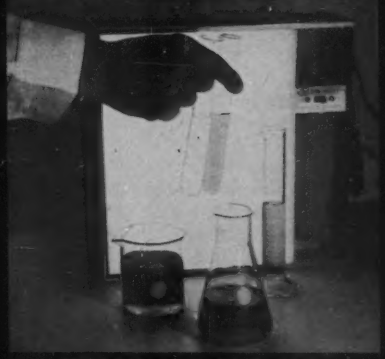

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■ RESISTIVITY MEASURING TEST SET for semi-conductor materials features easily interchangeable heads with separate heads for germanium and silicon and a 12-in. traversing platform, for long crystals, with visual scale of travel measure (see Fig. 1). Each probe is mounted on double ruby bushings, and a tolerance of 0.0001 in. variation in probe-point spacing is maintained in use. Accuracy is said to be ±2 percent. (Semimetals, Inc., Dept. Sci50, 133-20 91 Ave., Richmond Hill 18, N.Y.)

■ ISOLATION TRANSFORMER featuring low distributed capacitance between the secondary winding and ground furnishes 350 watts to permit isolating a complete instrument or a component circuit from ground. Shunt capacitance has been reduced to 40 pf. Leakage resistance for the secondary winding exceeds 100 kMohm, and breakdown voltage is greater than 5000. (Elcor Inc., Dept. Sci9, Falls Church, Va.)

■ MAGNETIC DETECTOR can measure the magnetic field intensity near the surface of recording media such as magnetic tapes, disks, and drums. The device, said to be capable of resolving 5×10^{-6} in.^{2}, comprises a high-gain, low-noise, narrow band-width amplifier and an indium antimonide Hall-effect probe. (Halex, Inc., Dept. Sci14, 310 E. Imperial Highway, El Segundo, Calif.)

■ REVERBERATION CHAMBER subjects parts to be tested to 150 db of acoustic power with a wide-band noise siren powered by air at 30-lb/in.^{2} pressure. Air consumption is 60-ft^3/min. The chamber is said to provide random frequency down 5 db at 100 cy/sec and down 10 db at 10,000 cy/sec; sinusoidal-input harmonic distortion is less than 15 percent. Volume of the chamber is 27 ft^3; 40 percent of the volume is usable. (PAM Associates, Inc., Dept. Sci57, 4127 Hayward Ave., Baltimore 15, Md.)

■ HUMIDITY METER is said to measure dewpoints as low as −150°C. The humidity sensor is a wire coated with a hygroscopic dielectric layer which in turn is coated with permeable gold. The capacitance of the sensor varies with the moisture content of the dielectric layer; the capacitance is indicated on the instrument dial. The capacitance change amounts to 0.1 μf, allowing considerable separation between sensor and indicating instrument. (Atkins Technical, Inc., Dept. Sci22, 1276 W. 3 St., Cleveland 13, Ohio)

■ PORTABLE FLOW CALIBRATOR is capable of handling jet fuel flow from 100 to 100,000 lb/hr with accuracy said to be ±0.25 percent of reading. Other ranges can be provided. The complete instrument weighs 250 lb. The calibrator employs three turbine-type flowmeters with overlapping ranges. The signals generated by the flowmeters drive digital instruments to indicate in 0.1-, 1-, and 10-lb increments. An air purging system permits the calibrator to be used in hazardous areas. (Potter Aeronautical Corp., Dept. Sci52, Union, N.J.)

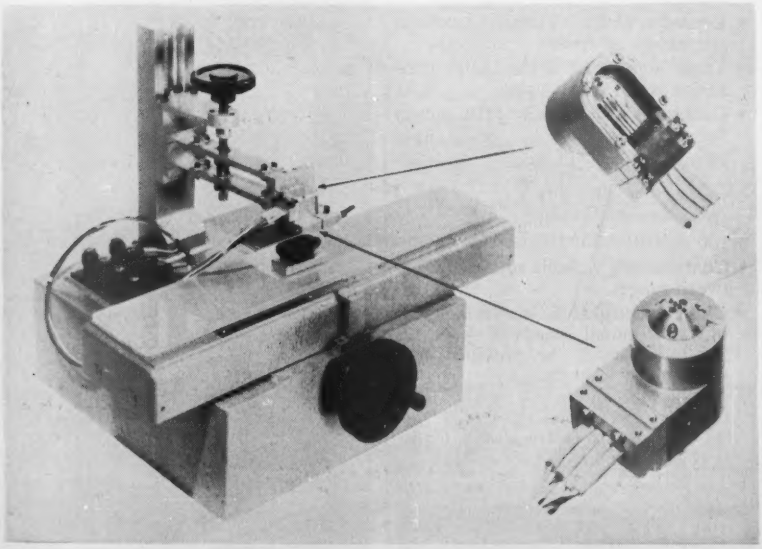

Fig. 1. Resistivity measuring test set.

■ POLAROGRAPHIC INSTRUMENT embodies the principles of a-c polarography. The voltage applied to the cell consists of low-level square waves superimposed on a slowly changing d-c polarizing voltage. The normal polarographic step is recorded as a peak whose maximum height occurs at the half-wave potential. The instrument is said to be capable of resolving elements whose half-wave potentials differ by as little as 20 mv. Accessories furnished include a thermostatically controlled constant-temperature bath, four cells, mercury pressurization system, nitrogen supply, and built-in monitoring oscilloscope and recorder. (Instrument Corporation of America, Dept. Sci20, 516 Glenwood Ave., Baltimore, Md.)

■ RECORDING FLOW PHOTOMETER charts photometric readings of a sample stream through three separate photometer channels arranged vertically in a straight line so that a single glass absorption cell lines up with the three light beams. The equipment is designed to be directly applicable to amino acid analysis. One measurement is made at 440 mμ with half-band-width of 16 mμ, and two measurements are made at 570 mμ and 7-mμ half-width at two optical path lengths. (Research Specialties Co., Dept. Sci44, 200 South Garrand Blvd., Richmond, Calif.)

■ DATA ACQUISITION SYSTEM is a solid-state recording system for acquisition and processing of operating and test data. The system consists of three components: a high-speed scanner in ten channel multiples, an analog-to-digital converter, and an output format control. The scanning and conversion equipment accepts low-level signals without preamplification. The format control receives digital information from either the analog-to-digital converter or from external channels. Also acceptable is digital information from clocks or counters. The format control converts the digital input information to the format required for magnetic-tape programming and computer entry. Input to the system is differential, and scanning speed is 600 channels per second. (Electro-Instruments, Inc., Dept. Sci35, 3540 Aero Court, San Diego, Calif.)

■ SOIL-RESISTANCE MEASURING UNIT measures soil resistivity up to 86,500 ohm/cm^3 when employed with a single rod resistivity setup. For determining anode resistance and other effects when two- or three-electrode setups may be employed, soil resistance up to 10,000 ohms may be measured. The instrument weighs 10 lb with self-contained battery supply. (Associated Research, Inc., Dept. Sci38, 3777 W. Belmont Ave., Chicago, Ill.)

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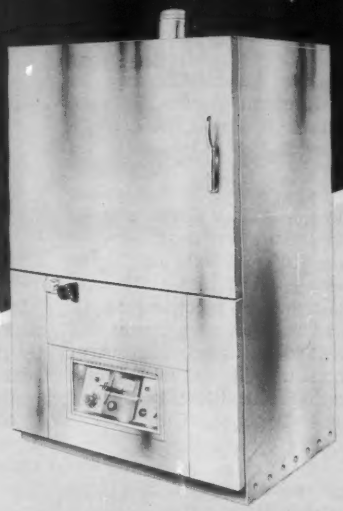

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■ SERUM-PROTEIN METER (Fig. 2) provides three-step analysis for protein in serum. The serum sample is centrifuged, the instrument is zeroed with distilled water, and the sample cell containing serum is then placed on the instrument, which reads directly in grams of protein per 100 ml. Sensitivity is 0.1 gram; range is 0 to 12 g/ml. A second scale reads refractive index difference to 0.0234. Measurement requires 2.5 ml of serum. (Bausch & Lomb, Inc., Dept. Sci60, Rochester 2, N.Y.)

■ PULSE GENERATOR furnishes pulses of variable repetition rate from 10 Mcy/sec to 100 cy/sec; duration variable between 0.05 and 1000 μsec; delay variable between 0.02 and 1000 μsec; rise time less than 10 nsec; and output amplitude 12 volts on open circuit and 8 volts into 180-ohm load. The instrument is transistorized and of modular construction. (Electro-Pulse, Inc., Dept. Sci37, 11861 Teale St., Culver City, Calif.)

■ MASS SPECTROMETER, type 21-110, is of the Mattauch-Herzog type in which a tandem arrangement of electric and magnetic fields focuses ions having the same mass but different initial velocities and directions. Mass range is 2 to 2000, and molecules differing in mass by 1 part in 2500 are said to be separable.

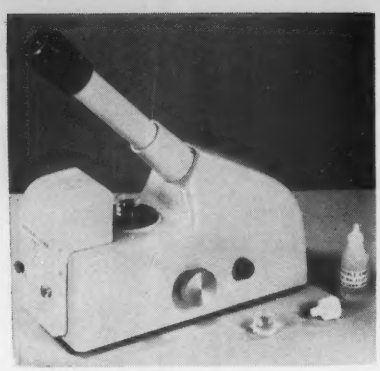

Fig. 2. Serum-protein meter.

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■ TRANSFER-FUNCTION ANALYZER obtains transfer functions, frequency by frequency, for random, complex, periodic, or sine wave driving signals. Output is provided in the form of Nyquist or Bode plots. The two signals to be analyzed are respectively the cause and effect signals from the device or system under test. Input-signal voltage levels between 1.0 and 10 volts r.m.s. are accepted. Input impedance is 1.5 Mohm. Operating frequency ranges are 0.5 to 3, 3 to 20, 20 to 200, and 200 to 2000 cy/sec. The input frequency to the unit is swept at a maximum rate of 1 octave in 15 sec; dynamic range is 50 db. Output signals, the in-phase and out-of-phase vector voltages within ±10 volts d-c, are fed to an X-Y recorder. Output signal errors are stated to be ±5 percent. (Gulton Industries, Inc., Dept. Sci40, P.O. Box 37, Princeton Junction, N.J.)

■ FLYING-SPOT PARTICLE RESOLVER is capable of automatically counting, sizing, and determining the area of microscopic particles within the field of view and of producing a picture of this field on a cathode-ray tube. The instrument also produces an electronic signal suitable for transmission to remote indicators. Magnification up to 8000 diameters is provided with 700-line definition and resolution of 10^{-4} cm. Alternative arrangements permit operation with microscope slides, 35-mm film, and 2-by-2-in. electron micrographs. The instrument can be applied to phase-contrast and dark-field microscope samples by first photographing the samples and using a 35-mm film adapter. (Instrument Corporation of America, Dept. Sci46, 1545 Kennewick Rd., Baltimore 18, Md.)

■ INTEGRATOR for standard strip-chart recorders reads out the integral on demand with accuracy said to be ±0.25 percent of full scale. On a 10-in. wide strip chart moving at 1 in./min, readout accuracy corresponds to 0.004 in. of input. The integral is read back into the recorder itself when the operator judges that integration has been completed. The integrator is then reset automatically, and the pen is returned to zero for the next integration. With the addition of a zero-sensing device, the integrator becomes a fully automatic integrating and peak-transmitting device for gas chromatograms. (Schlumberger Well Surveying Corp., Dept. Sci41, Ridgefield, Conn.)

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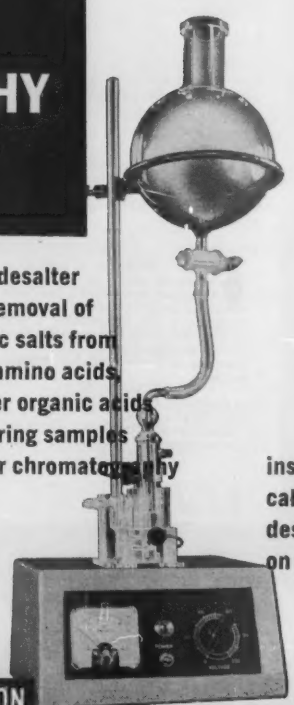

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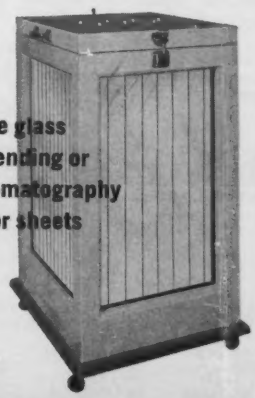

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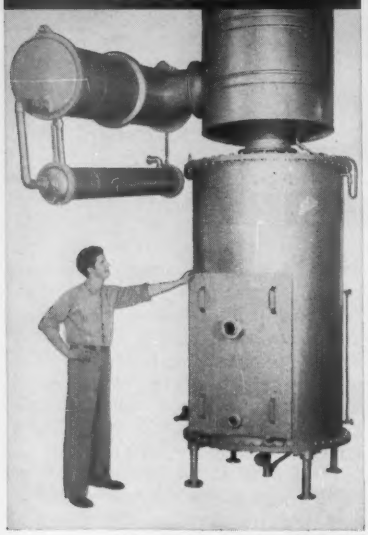

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easily accessible for inspection and repair. Included in the tester are a tape transport, a push-button control unit, dual record-playback head, amplifiers, and a logic chassis with fault detector plug-in cards and space for 16 channels. (Potter Instrument Co., Dept. Sci13, Sunnyside Blvd., Plainview, N.Y.)

■ PULSE GENERATOR is capable of delivering simultaneously a positive and negative pulse of 2 to 100 nanosecond duration. Rise time is 0.5 nsec, and repetition rate is adjustable between 10 and 100,000 pulses per second. Pulse amplitude is fixed at approximately 8 volts into 50 ohms. Output pulses are preceded by trigger pulses with time difference adjustable over a 100-nsec range. Triggering can be effected by an external source delivering a positive pulse. Because the instrument is all electronic (no mercury switches are used), it can operate in any position. (Edgerton, Germeshausen & Grier, Inc., Dept. Sci19, Boston, Mass.)

■ VACUUM PUMPING SYSTEM is a fractionating 6-in. diffusion pump complete with refrigeration, Chevron-type baffle, and hand-operated butterfly valve. The baffle is refrigerated to approximately −30°C by a self-contained, hermetically sealed unit. The system is designed particularly for compactness, over-all height being less than 28 in. Ultimate pressure is said to be less than 5×10^{-7} mm-Hg. (Edward High Vacuum Inc., Dept. Sci36, 1920 Buffalo Ave., Niagara Falls, N.Y.)

■ COLOR GENERATOR, for color matching, reconstructs natural daylight by use of color filters, and incandescent, fluorescent, and ultraviolet tubes which are blended by simple preset controls to duplicate the desired type of light. Two table-top models are available, one of which is equipped with a shield that keeps extraneous light away from the object being illuminated. (Gamain Company, Dept. Sci63, 5th and Richmond Sts., Kansas City, Kan.)

■ THERMAL TEST SET for measurement of transistor and diode temperatures and other temperatures encountered in electronic equipment design is direct reading; ambient temperature compensation is provided. Accessories include small thermoelectric junctions, a thermometer probe, and evacuated glass thermocouples. Switches permit selection of any one of four outputs. (Rescon Electronics Corp., Dept. Sci62, 151 Bear Hill Rd., Waltham 54, Mass.)

■ OZONE RECORDER, model 725-3B, covers the operating range 0 to 100 parts per million by volume. The record is produced on a 6-in. strip chart directly in terms of ozone concentration. Measurement of ozone is based on an electrochemical reaction occurring at polarizing electrodes immersed in a potassium iodide reagent solution. Sampling rate is approximately 140 cm^3/min. Sensitivity is ±2 percent of full scale, and response time is 1 min for 75-percent response. Power requirement is 110 volt a-c (100 watts) and one 1.34-volt mercury cell. The instrument will operate unattended for approximately 3 days. (Mast Development Co., Dept. Sci68, Davenport, Iowa)

■ HYDRAULIC JACK is designed to apply and maintain the precise loads necessary for use with calibrating instruments, such as proving rings, in the calibration of mechanical-force measuring equipment. A large piston in the pump operates until the pressure reaches approximately 750 lb/$in.^2$, after which smaller piston becomes effective. Available capacities are 10,000, 30,000 60,000, and 100,000 lb. (Morehouse Machine Co., Dept. Sci49, 1742 Sixth Ave., York, Pa.)

■ CROSSBAR SCANNER provides a 100-channel, six-pole-per-channel capacity which can be readily altered to exchange poles for increased channels. According to the manufacturer, life of the scanner is 20,000,000 operations per cross point. Scanning speeds range up to 50 closures per second per pole. A logic chassis provides commands of start, step, stop, return to "off," reset to zero, designate channel *N* as first, designate

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channel X as last, and scan continuously. Appropriate combinations of these commands provide flexible programming. (James Cunningham, Son & Co., Dept. Sci16, Rochester 8, N.Y.)

■ REMOTELY OPERATED MICROMETER consists of a micrometer head operating on the screw principle, an electronic control console, and connecting cable. Digital readout to $\pm 10^{-5}$ in. is displayed on the console. Measuring range is 1 in. The head can be remotely zeroed at any point within its measuring range. The micrometer head is said to exert negligible pressure on the work. (J. W. Dice, Dept. Sci7, Englewood, N.J.)

■ LIQUID NITROGEN LEVEL CONTROLLER uses a temperature sensing element that sends a signal to a magnetic amplifier if the temperature is above a pre-set range. The amplifier will then cause a solenoid valve to open, admitting more liquid coolant to the baffle. When the required lower temperature is again reached, a second signal from the sensing element causes the solenoid valve to close and turn off the coolant supply. (Consolidated Vacuum Corp., Dept. Sci51, 1775 Mt. Read Blvd., Rochester 3, N.Y.)

■ MONITORING OSCILLOSCOPE will simultaneously display up to eight waveforms on a vertically mounted 17-in. cathode-ray tube. Repetitive and single-sweep speeds of 5, 2.5, and 1.5 in./sec are provided. A 25-sec single sweep is also available. Sweep linearity is said to be better than 3 percent. Frequency response of the gating amplifiers is said to be from d-c to 1000 cy/sec; response is 3 db down at 1000 cy/sec. (Sanborn Co., Dept. Sci42, 175 Wyman St., Waltham 54, Mass.)

■ MICROORGANISM MILL reduces bacteria, spores, molds, yeast, and pollen granules in hopper capacities ranging from 150 ml to 2 lit. Glass beads, approximately 120 μ in diameter, are incorporated to mix with the slurry, and a set of cutter knives assists in keeping the slurry in suspension. Final refining is performed by hard-faced 2-in. rotor and stator with gap adjustable between 0.0005 and 0.125 in. The equipment is completely enclosed to provide a controlled atmosphere. (Gifford-Wood Co., Dept. Sci33, Hudson, N.Y.)

■ X-RAY DIFFRACTOMETER, manufactured by Hilger & Watts, can be used with x-ray equipment having a tube window not less than 10½ in. above the table on which the diffractometer stands. The diffractometer has double-beam operation and six scanning speeds with continuous scanning. A powder sample holder, a block sample holder, and an integrating holder for heterogeneous

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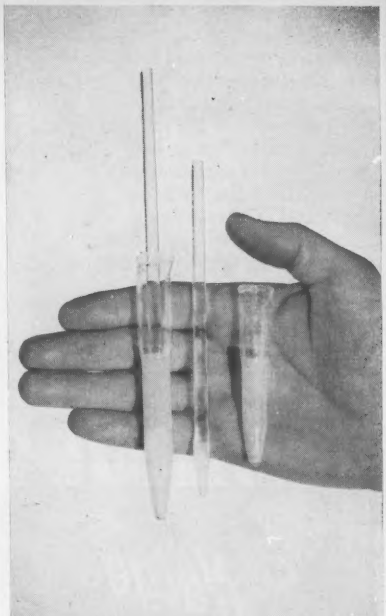

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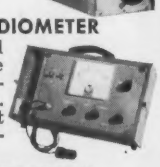

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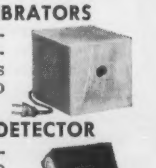

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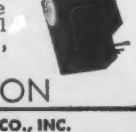

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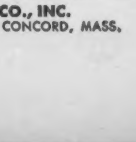

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samples may be interchanged. Alternative detectors include Geiger-Mueller counter, scintillation counter, or semiproportional counters. A two-circle version of the diffractometer is intended for work with single crystals. Its detector can be tilted up to 50 deg for measuring reflections above the equatorial plane. (Engis Equipment Co., Dept. Sci61, 431 S. Dearborn St., Chicago 5, Ill.)

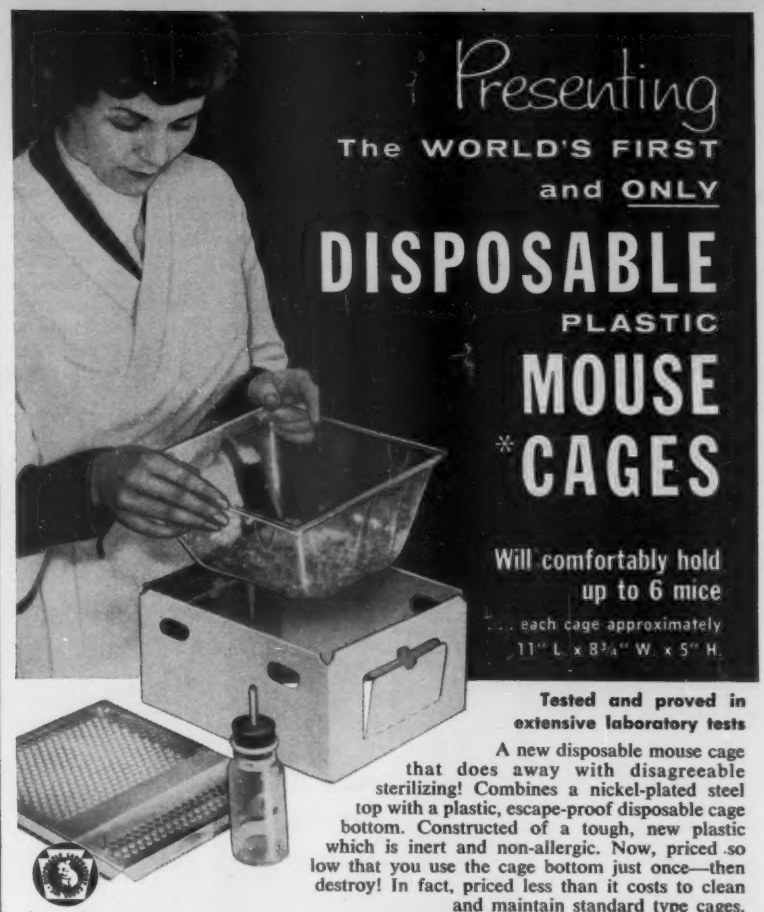
■ ELECTROLYTIC PROCESS UNIT for hard anodizing, plating, or electrochemical milling consists of a Lucite plating tank equipped with anode and cathode racks, cooling coil, and agitator; a 20-amp rectifier; and a ¼-ton refrigeration unit; the components are assembled into a desk-size unit 45 by 22 by 40 in. high. Optional equipment includes an immersion heater. Operation is on 120 volts a-c. (Allen Aircraft Products, Inc., Dept. Sci39, Ravenna, Ohio)

■ POLAROGRAPHIC ANALYZER provides 23 current ranges from 0.5 to 300 μa full scale and ten polarizing ranges, from +1½ to −5 volts. Accuracy of the unit is said to be ±½ percent for current and voltage, repeatability ±¼ percent. The recorder chart is 5 in. wide; chart speed is ½ in./min. Bridge drive is synchronous, with a rotation time of 10 min. Standardization is manual against an internal cell. (Nesco Instruments, Inc., Dept. Sci43, 638 W. 17 St., Costa Mesa, Calif.)

■ PHASE-SHIFTING TRANSDUCERS are designed for use at specific frequencies to provide an output signal the phase of which is a function of shaft rotation. Maximum operating speed is 5000 rev/min. The transducers are complete phase-shifting systems, consisting of capacitor, bridge network, and balanced-line components in a single housing; components are capacitance coupled. (Nilsen Manufacturing Co., Dept. Sci48, 23 N. Church St., Addison, Ill.)

■ TWO-PEN, TWO-AXIS RECORDER includes three servo-actuated drives for x, y, and y_2, isolated from ground. Recording speed is 1½ sec full scale on x-axis and ½ sec full scale on the y-axes. Full-range zero set and one full scale of zero suppression are provided on each axis. Ten input voltage ranges from 7.5 mv to 150 v are provided on the x-axis, and ten ranges from 5 mv to 100 v are provided on the y-axes. (F. L. Moseley Co., Dept. Sci15, 409 Fair Oaks Ave., Pasadena, Calif.)

■ CONDUCTIVITY INSTRUMENT for measurement of flowing solutions covers a range of 5×10^{-6} to 4 mho with three continuous flow cells. Hold-up volumes are 0.02 to 0.05 ml. A discriminator



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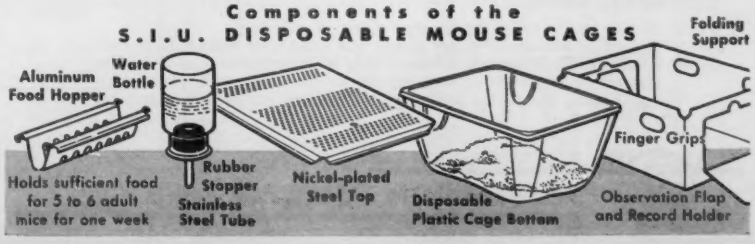

circuit reduces the influence of varying cell resistance. Connection can be made to a *Z* jack for impedance measurements. (LKB Instruments, Inc., Dept. Sci17, 4840 Rugby Ave., Washington 14, D.C.)

■ RUNNING-TIME METERS, housed in multiples of ten in a 7-by-13-in. housing, are available for reading to the nearest hour and tenth, tenth and hundredth, or minute and tenth. Signal lights, one for each meter, indicate when time is being accumulated. The unit operates on 26 volts. (Gorrell & Gorrell, Dept. Sci30, Westwood, N.J.)

■ SEMICONDUCTOR STRAIN GAGE, model MS 105-350, is said to be bondable to practically all surfaces. The gage, measuring 1 by 0.5 in., consists of a thin silicon element ⅝ in. long, 0.020 in. wide and 0.0005 in. thick, attached to an epoxy based carrier for application to test surfaces. Integral lead tabs are provided for connection to instrumentation systems. Resistance of the gage is 350 ohms; gage factor is approximately 130. Operating temperature range is −65° to +180°F. Maximum operating strain is greater than 3000 μin./in. (Micro Systems, Inc., Dept. Sci64, 2925 E. Foothill Blvd., Pasadena, Calif.)

■ STANDARD-GAIN ANTENNAS consist of a series of 14 broad-band waveguide horns that cover the microwave bands from 0.95 to 90 kMcy/sec. Horns are made of anodized aluminum or plated brass of light-weight construction. Each horn is furnished with data on gain versus frequency characteristics. (Scientific-Atlanta, Inc., Dept. Sci55, 2162 Piedmont Rd., N.E., Atlanta 9, Ga.)

■ ELECTRONIC STETHOSCOPE, manufactured by Primo Sound Research Ltd., Tokyo, Japan, is said to amplify up to 100 times more than the conventional stethoscope. High and low filters permit unwanted sounds to be eliminated. An output is provided to feed a tape recorder, oscilloscope, or other instrument. Power is supplied by 6 penlite cells. (Trans-Pacific Electronics, Inc., Dept. Sci18, 4216 Lankershim Blvd., North Hollywood, Calif.)

■ SLIDE FILING CABINET accommodates 2340 slides, 2 by 2 in., or 78 slides, 4 by 3¼ in., or combinations. Slides are said to be easily removed and replaced and can be viewed against a light-diffusing frame included in the cabinet. (Multiplex Display Fixtures Co., Dept. Sci23, 910 N. 10 St., St. Louis 1, Mo.)

■ RECORDER of null-balance servo potentiometer type with chopper-stabilized system has a full-scale span of 1 mv. Maximum source resistance is 50 kohm. Pen speed is ½ sec for full-scale traverse, and accuracy is said to be ±0.5 percent of full scale. Voltage ranges up to 10 v can be selected from a front-panel attenuator. Chart width is 5 in.; chart speed can be changed. (Nesco Instruments Inc., Dept. Sci53, 638 W. 17 St., Costa Mesa, Calif.)

■ VACUUM GAGE uses tritium to provide ionization. The isotope forms part of the inner metal surface of the instrument. The gage covers the range 0.001 to 100 mm-Hg. Ionization current is produced by a 45-volt battery and is measured by a microammeter. According to the manufacturer, there is no detectable external radiation; no special licensing is required. (Radiation Research Corp., Dept. Sci54, 1114 First Ave., New York 21, N.Y.)

■ COMPONENT DISPENSER cuts and bends axial leads of electronic components into desired configuration automatically or semiautomatically. Cutting and bending dies are said to be adjustable in less than 1 min; runs of 10 to 20 components are economical. Storage capacity is 48 in six hopper chutes. (Schmit Engineering Co., Dept. Sci56, 4062 Fabian Way, Palo Alto, Calif.)

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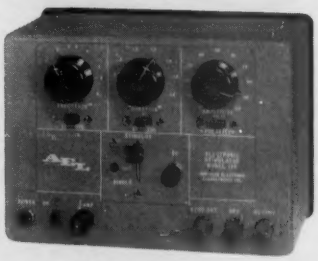

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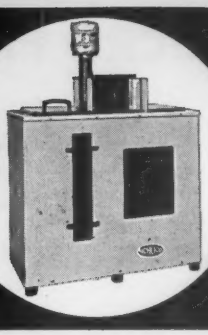

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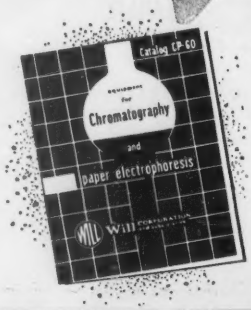

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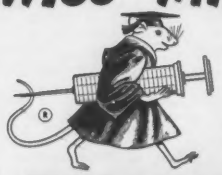

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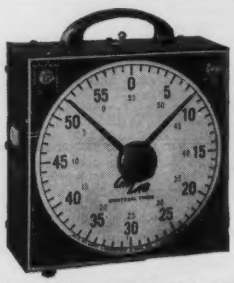

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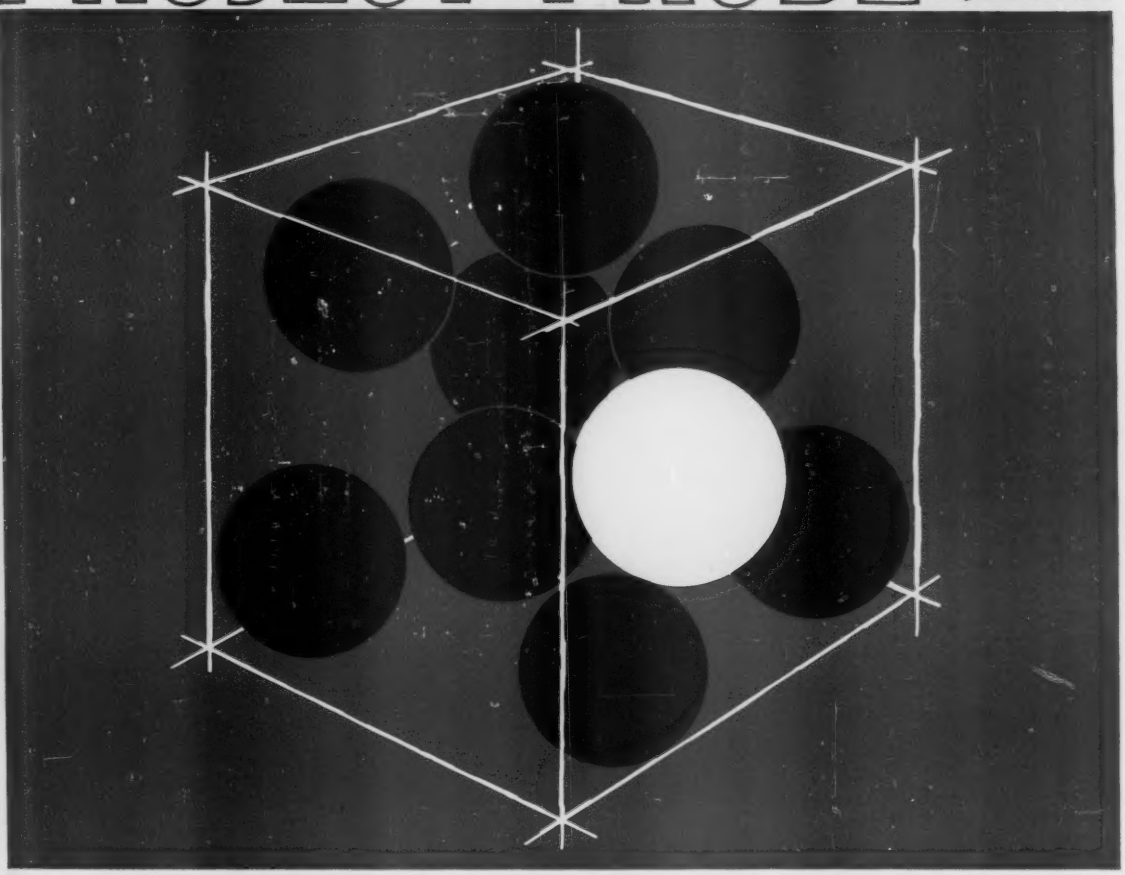

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